Baseline Ecological Risk Assessment for Dick's Creek and Monroe Ditch

AK Steel
Middletown, Ohio

Submitted to:

U.S. Environmental Protection Agency
Region 5
77 West Jackson Blvd.
Chicago, IL 60604

Prepared by:

Dr. Mace G. Barron, Ph.D.
ASE, Inc./Booz Allen Hamilton Inc.

EPA Work Assignment No.:	R05802
Contract No.:	68-W-02-018
EPA WAM:	Allen Wojtas
Telephone No.:	312/886-6194
EPA Technical Lead:	Gary Cygan
Telephone No.:	312/886-5902

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Acronym List

ADD	average daily dose
AH	affected habitat
AUF	area use factor
AWQC	ambient water quality criteria
BAF	bioaccumulation factor
BERA	baseline ecological risk assessment
CBR	critical body residue
COC	contaminant of concern
COPC	contaminant of potential concern
CSM	conceptual site model
dw	dry weight
ED	exposure duration
EDQL	ecological data quality level
EPC	exposure point concentration
ERA	ecological risk assessment
HQ	hazard quotient
HR	home range
LOAEL	lowest observed adverse effect level
NOAEL	no observed adverse effect level
OC	organic carbon
OEPA	Ohio EPA
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCDDs	polychlorinated dibenzo-p-dioxins
PCDFs	polychlorinated dibenzofurans
QHEI	Qualitative Habitat Evaluations Index
SV	screening value
TEC	toxicity equivalence concentrations
TEF	toxicity equivalency factor
tPAH	total polycyclic aromatic hydrocarbons
TRV	toxicity reference value
USEPA	U.S. Environmental Protection Agency
ww	wet weight

Executive Summary

This baseline ecological risk assessment (BERA) report assesses the risks of contaminants from the AK Steel Corporation facilities (AK Steel site) in Middletown, Ohio to ecological receptors using and inhabiting Dick's Creek, Monroe Ditch, and the Dick's Creek floodplain (the Dick's Creek system). Note that Monroe Ditch is a stream and not a ditch. The June 2002 site visit by Dr. Barron showed that Monroe Ditch had flowing water with multiple pools and riffles, a well-developed riparian area, and a meandering stream channel.

The BERA has been prepared according to current U.S. Environmental Protection Agency (USEPA) guidance, including problem formulation, analysis of exposure and effects, and risk characterization (USEPA, 1997, 1998, 2001). The general approach followed in this BERA was an initial screening of risks from a broad range of contaminants to identify contaminants of concern (COCs), followed by a comprehensive and quantitative assessment of COC risks to aquatic organisms and wildlife. The initial risk screening was performed in the Problem Formulation section of the BERA and corresponded to Step 3 of the USEPA (1997) ecological risk assessment process. A screening-level ERA [Steps 1 and 2 of the USEPA (1997) risk process] was not performed because the potential for ecological risks had already been identified in two previous risk assessments.

Problem Formulation

Dick's Creek is a stream in southwest Ohio that has received polychlorinated biphenyls (PCBs) and other contaminant releases from the AK Steel site. Dick's Creek is in the Ohio River basin and generally flows east to west to its confluence with the Great Miami River (river mile 0). Dick's Creek is in proximity to the southern portion of the AK Steel site, which includes the Olympic Mill Services (OMS) facility from approximately river miles 2.5 to 4. Monroe Ditch flows north and west through the OMS facility to its confluence with Dick's Creek at approximately river mile 2.5.

A hazard quotient (HQ) approach was first used to identify COCs using a systematic and moderately conservative screening process of comparing maximum detected contaminant concentrations and lowest observed adverse effect level (LOAEL) screening values. LOAELs were used in the initial risk screening to focus the BERA on contaminants that were most likely to pose risks, in contrast to a screening level ecological risk assessment (SERA), which uses no observed adverse effect concentrations (NOAELs) to identify contaminants of potential concern (COPC). NOAELs were used only in the initial risk screening if LOAELs were not available in standard references to identify COPCs qualitatively considered in the BERA. Exposure point concentrations were calculated for detected contaminants using only data collected since 1999 because these data were considered to be most representative of current conditions. Non-detected analytes were excluded from consideration because of the extensive data sets for surface water and sediment and the need to focus the BERA on the most likely risk drivers. PCB risks to wildlife were screened using either measured or estimated concentrations in prey or forage.

PCBs were identified as the only COC in the Dick's Creek system, although a number of COPCs were identified and are discussed in the uncertainty section of the BERA. PCBs were determined to be a COC for the following receptors and exposure pathways: (1) benthic invertebrate contact with sediment, (2) fish contact with surface water and accumulation of toxic body residues, (3) piscivorous wildlife ingestion of surface water, benthic invertebrates, fish, and sediment (incidental), and (4) terrestrial wildlife ingestion of soil invertebrates, small mammals, and soil (incidental). PCB risks to other types of ecological receptors were determined to be low.

<u>Analysis of PCB Exposure and Effects</u>

Only data collected since 1999 for total PCBs in surface water, surface sediment, groundwater seeps, floodplain surface soils, and biota were used because they were considered to be most representative of current conditions. Data were obtained from three sources: AK Steel/Arcadis, Ohio EPA, and USEPA. Total PCB concentrations in sediment were normalized to 1% organic carbon (OC) for the assessment of risks to benthic invertebrates because OC is a determinant of PCB toxicity. Whole body fish concentrations (estimated from fish fillet data) were also used in the weight-of-evidence assessment of the BERA.

Multiple AK Steel sources of PCBs exist along the site, including contaminated groundwater seeps, Outfall 002 sediments, and Monroe Ditch. The available data consistently show that PCBs substantially increase in sediment, aquatic plants, benthic invertebrates, and fish collected downstream of these source areas. PCBs are low or not detectable in upstream areas. PCB contamination has been detected for over three miles of Dick's Creek to nearly its confluence with the Great Miami River, and the available recent data (1999 to 2003) do not show any apparent declines in PCB concentrations in Dick's Creek.

The ecological receptors quantitatively assessed in the BERA included: aquatic organisms (benthic invertebrates, fish), piscivorous wildlife (mink, raccoon, kingfisher), and terrestrial wildlife (robin, kestrel). These receptors were selected because the initial screening assessment indicated they may be at risk, they are ecologically and toxicologically relevant (e.g., sensitive, potential high exposure, known to occur in Dick's Creek or regionally), and adequate data are available for exposure modeling (e.g., home range, life history, dietary parameters). Additionally, these receptors represent a diversity of exposure pathways and feeding habits, including ingestion of aquatic organisms and terrestrial prey organisms.

Both NOAEL and LOAEL toxicity reference values (TRVs) were used in quantitatively assessing PCB risks to ecological receptors in the Dick's Creek system. USEPA (1997) and ORNL (1998) considered these values to be the lower and upper thresholds for ecological effects. Exceedence of a TRV is indicative of ecological effects. Exceedence of a LOAEL TRV indicates greater certainty that risks are present than exceedence of a NOAEL value.

Risk Characterization

A probabilistic assessment of total PCB risks was used to estimate risks to benthic invertebrates, fish, and wildlife because this approach incorporated the variability and uncertainty in exposure and toxicity and provided directly interpretable risk descriptions for risk managers. Additionally, the risks of dioxin-like PCB congeners to piscivorous wildlife and fish were estimated and considered in the weight-of-evidence assessment. Probabilistic HQ exceedences using both NOAEL and LOAEL TRVs indicated the potential for risk, and HQ exceedences of LOAEL TRVs were considered to be evidence that risks were present. Both the magnitude and probability of the HQ exceedences were considered in the weight-of-evidence assessment.

The available lines of evidence show that benthic invertebrates are at risk from total PCBs in Dick's Creek sediment downstream of AK Steel PCB sources. This conclusion is considered to be of high confidence because the spatial extent of PCB contamination has been well characterized, and risks were determined using TRVs indicative of potential population-level effects. The probability of exceeding median effect concentrations was 79%. Additionally, a qualitative evaluation of the results of recent ecological surveys and in-situ toxicity tests also indicated adverse effects of contaminated sediments.

The available lines of evidence show that fish may be at risk from total PCBs in Dick's Creek downstream of AK Steel PCB sources. This conclusion is considered to be of high confidence because the spatial extent of PCB bioaccumulation has been well characterized in fish, and risks were determined using TRVs indicative of adverse effects on a variety of fish species. The probability of exceeding the LOAEL TRV was 6% and the probability of risks was 30% using the NOAEL and LOAEL range.

The available lines of evidence show that PCB risks to piscivorous wildlife are species-specific. Mink have a 90 to 100% probability of exceeding LOAELs from ingestion of total PCBs and dioxin-like PCBs. The conclusion of risks to mink is considered to be of high confidence because of the high probability of exceeding TRVs indicative of potential population-level effects. Kingfishers and raccoons feeding in the Dick's Creek system did not appear to be at risk from ingestion of total PCBs, but kingfishers were at risk from ingestion of dioxin-like PCB congeners. Kingfishers had a 99% probability of exceeding LOAEL TRVs based on toxicity equivalence concentrations of dioxin-like PCBs in aquatic prey.

The available lines of evidence show that PCB risks to terrestrial wildlife are species-specific. Robins had a 10.8% probability of exceeding LOAEL TRVs based on total PCBs in soil invertebrates. Kestrels did not appear to be at risk from ingestion of PCBs. Dioxin-like PCB congener data were not available for terrestrial prey species.

Background risks appear to be minimal or nonexistent in Dick's Creek, as evidenced by non-detections or very low contamination measured in sediment, aquatic plants, benthic invertebrates, and fish upstream of AK Steel PCB source areas.

Uncertainty Analysis

The principal uncertainty in the BERA was that the assessment was primarily based on total PCBs, which may result in an over- or underestimation of ecological risk. Risks were more likely underestimated for both total PCBs and dioxin-like PCB congeners because (1) the majority of total PCB data were determined using analytical methods that may underestimate total PCB concentrations in Dick's Creek, and (2) dioxin-like PCB exposure and risks were not assessed for a number of ecological exposure pathways because of limited data. Secondary sources of uncertainties include the spatial extent of PCB contamination in the Dick's Creek floodplain, the risks to plants and soil invertebrates, the risks of non-detected chemicals, and the relatively few COPCs.

Conclusions

Monroe Ditch and Dick's Creek are contaminated with PCBs from approximately river mile 3 to near the confluence with the Greater Miami River (river mile 0). PCB contamination is present in surface and subsurface sediments, floodplain soils, and aquatic organisms downstream of apparent AK Steel source areas. Aquatic organisms and wildlife are at risk from PCBs in the Dick's Creek system downstream of AK Steel site source areas of PCBs. In contrast, PCB levels are low or non-detectable in upstream areas and are unlikely to pose risks to aquatic organisms and wildlife. These conclusions are considered to be of high confidence and consider the variability and uncertainty in PCB exposure and toxicity. PCB risks in the Dick's Creek system are more likely to be underestimated rather than overestimated from the approach used in this BERA.

1. Introduction

This baseline ecological risk assessment (BERA) report assesses the risks from contaminants from the AK Steel Corporation facilities (AK Steel site) in Middletown, Ohio to ecological receptors using and inhabiting Dick's Creek, Monroe Ditch, and the Dick's Creek floodplain (the Dick's Creek system). Note that Monroe Ditch is a stream and not a ditch. A June 2002 site visit by Dr. Barron showed that Monroe Ditch had flowing water with multiple pools and riffles, a well-developed riparian area, and a meandering stream channel.

1.1 Overview

Dick's Creek is a stream in southwest Ohio that has received polychlorinated biphenyls (PCBs) and other contaminant releases from the AK Steel site as described in Section 2 of this BERA. Photographs and ecological descriptions of the Dick's Creek system are provided in Section 2 and Appendix C.

Two recent ecological risk assessments (ERAs) have been previously reported for Dick's Creek.

- AquaQual. 2001. *Ecological Risk Assessment of Dick's Creek, Middletown, Ohio.* AquaQual Services, Inc. Prepared for Tetra Tech and the USEPA. April 30, 2001.

- Arcadis. 2001a. *Ecological Risk Assessment for Dick's Creek. Arcadis G&M, Inc.* Prepared for AK Steel Corp. June 1, 2001.

Neither ERA considered all of the recent data and information collected by AK Steel contractors (i.e., Arcadis G&M [Arcadis]), the Ohio Environmental Protection Agency (OEPA), the United States Environmental Protection Agency (USEPA), and USEPA contractors (AquaQual) that existed at the time of those assessments. Also, the results of these two ERAs were contradictory and highly uncertain. Because of these concerns, USEPA contracted Booz Allen Hamilton to perform and report an assessment of ecological risks of AK Steel site contaminants in Dick's Creek. This ERA was performed by Dr. Mace Barron of ASE, Inc., which is a wholly owned subsidiary of Booz Allen Hamilton. Along with data used in the two previous ERAs, this BERA also incorporates more recent data from fish, sediment, and floodplain soil sampling and analyses performed by OEPA and USEPA.

1.2 Guidance Used

Current USEPA guidance was used in preparing this ERA, including:

- USEPA. 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. EPA 540-R-97-006. U.S. Environmental Protection Agency, Edison, NJ.

- USEPA. 1998. *Guidelines for Ecological Risk Assessment.* EPA/630/R-95/002F. U.S. Environmental Protection Agency, Washington, D.C.

- USEPA. 1999a. *Risk Assessment Guidance for Superfund: Volume 3 - (Part A, Process for Conducting Probabilistic Risk Assessment).* Revision No. 5. U.S. Environmental Protection Agency, Washington, D.C. Draft. December 1999. www.epa.gov/superfund/progress/risk/rags3adt/index.htm

- USEPA. 2001. *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments.* ECO Update. EPA 540/F-01/014. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. June 2001.

The assessment of risks of dioxin-like PCB congeners in the Dick's Creek system and inclusion in the weight-of-evidence evaluation of the BERA was consistent with USEPA (2003c):

- USEPA. 2003c. Framework for Application of the Toxicity Equivalence Methodology for Polychlorinated Dioxins, Furans and Biphenyls in Ecological Risk Assessment. EPA/630/P-03/002A. U.S. Environmental Protection Agency. June 2003. External Review Draft.

Additionally, current OEPA (2003) guidance on performing ecological risk assessments at RCRA sites was considered:

- OEPA. 2003. *Guidance for Conducting RCRA Ecological Risk Assessments.* State of Ohio, Environmental Protection Agency. March 2003.

1.3 Report Purpose and Organization

This report quantitatively and qualitatively evaluates the risks of AK Steel site contaminants on ecological receptors using and inhabiting the Dick's Creek system. The purpose of this report is to provide a defensible and comprehensive assessment of ecological risks to support a scientific basis for making remedial/corrective action decisions regarding the site. This report is organized according to the components of an ERA (e.g., USEPA, 1997, 1998) including problem formulation (Section 2), data used (Section 3), exposure analysis (Section 4), effects analysis (Section 5), and characterization of risks and uncertainties (Section 6). Section 7 provides the summary and conclusions, and Section 8 lists the information cited. The appendices of the report provide a presentation of: (A) determination of contaminants of concern (COCs), (B) wildlife exposure parameters, (C) derivation of wildlife screening values for polycyclic aromatic hydrocarbons (PAHs), (D) June 2002 site visit and photographs, (E) OEPA and USEPA additional data collection activities, (F) total PCB data used in the BERA, and (G) dioxin-like PCB congener data used in the BERA.

2. Problem Formulation

2.1 Overview

This problem formulation section describes the environmental setting (Section 2.2), identifies potential contaminant sources and transport pathways (Section 2.3), identifies the COCs through a process of screening potential site contaminants (Section 2.4), describes ecological exposure and effects of the COCs (Section 2.5), selects the assessment and measurement endpoints and presents the conceptual site model (CSM) (Section 2.6), and describes the rationale for performing a BERA for PCBs at the scientific/management decision point (Section 2.7). The BERA is focused on the Dick's Creek system that includes Monroe Ditch, Dick's Creek, and the Dick's Creek floodplain.

The initial risk screening was performed in this Problem Formulation section of the BERA and corresponded to Step 3 of the USEPA (1997) ecological risk assessment process. A screening-level ERA [Steps 1 and 2 of the USEPA (1997) risk process] was not performed because the potential for ecological risks had already been identified in two previous risk assessments.

2.2 Environmental Setting

2.2.1 Location and Description

Dick's Creek and the AK Steel site are located near Middletown in southwest Ohio (Figure 2.1), in the Ohio River basin. Figure 2.2 presents an aerial photograph showing Dick's Creek, Monroe Ditch, the North Branch of Dick's Creek and the AK Steel site. For the purposes of this BERA, the AK Steel site is defined as facility areas located on both the north and south side of Dick's Creek, including those associated with OMS operations. Dick's Creek generally flows east to west to its confluence with the Great Miami River (river mile 0) and is in proximity to the AK Steel site from approximately river mile 2.5 to 5.5 (Arcadis, 2001a). Production of steel, pig iron, coke, slag processing, and steel finishing and coating occur at the AK Steel site.

2.2.2 Habitat, Aquatic Organisms and Wildlife

General habitat descriptions and wildlife observations are provided in the previous AK Steel (Arcadis, 2001a) and USEPA (AquaQual, 2001) contracted ERAs, including:

- The area surrounding Dick's Creek includes: 3% open water, 2% non-forest wetland, 14% woodlands, 0.2% shrub land, 51% agriculture/open land, 29% urban land, and 1% barren land (Arcadis, 2001a).

- Dick's Creek is classified as a lower perennial, riverine, unconsolidated bottom, permanently flooded habitat, with water depths ranging from 0.5 to 4 feet (Arcadis, 2001a).

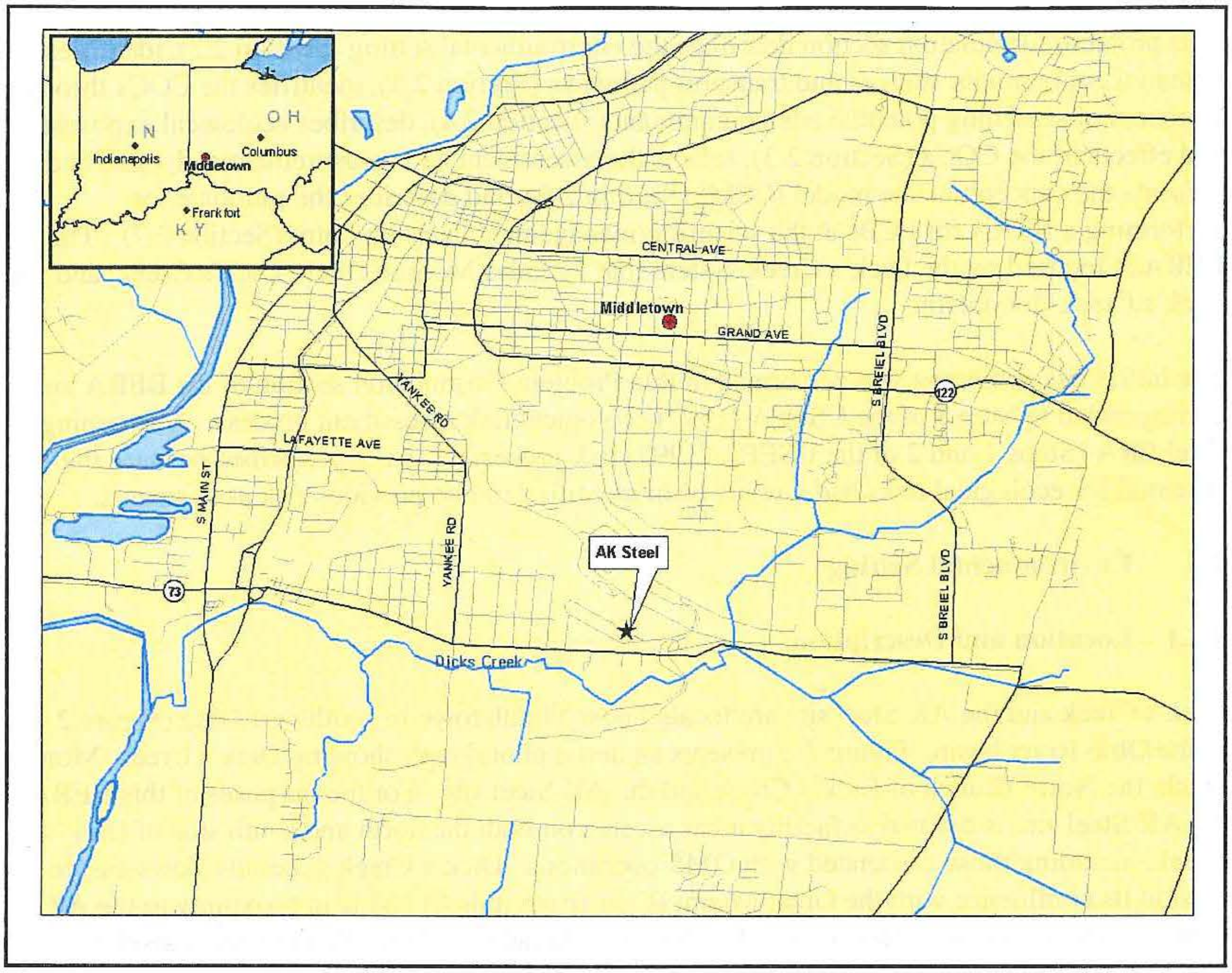

Figure 2-1. Map of Middletown, Ohio, showing location of AK Steel site (star), and Dick's Creek. Inset map shows regional location.

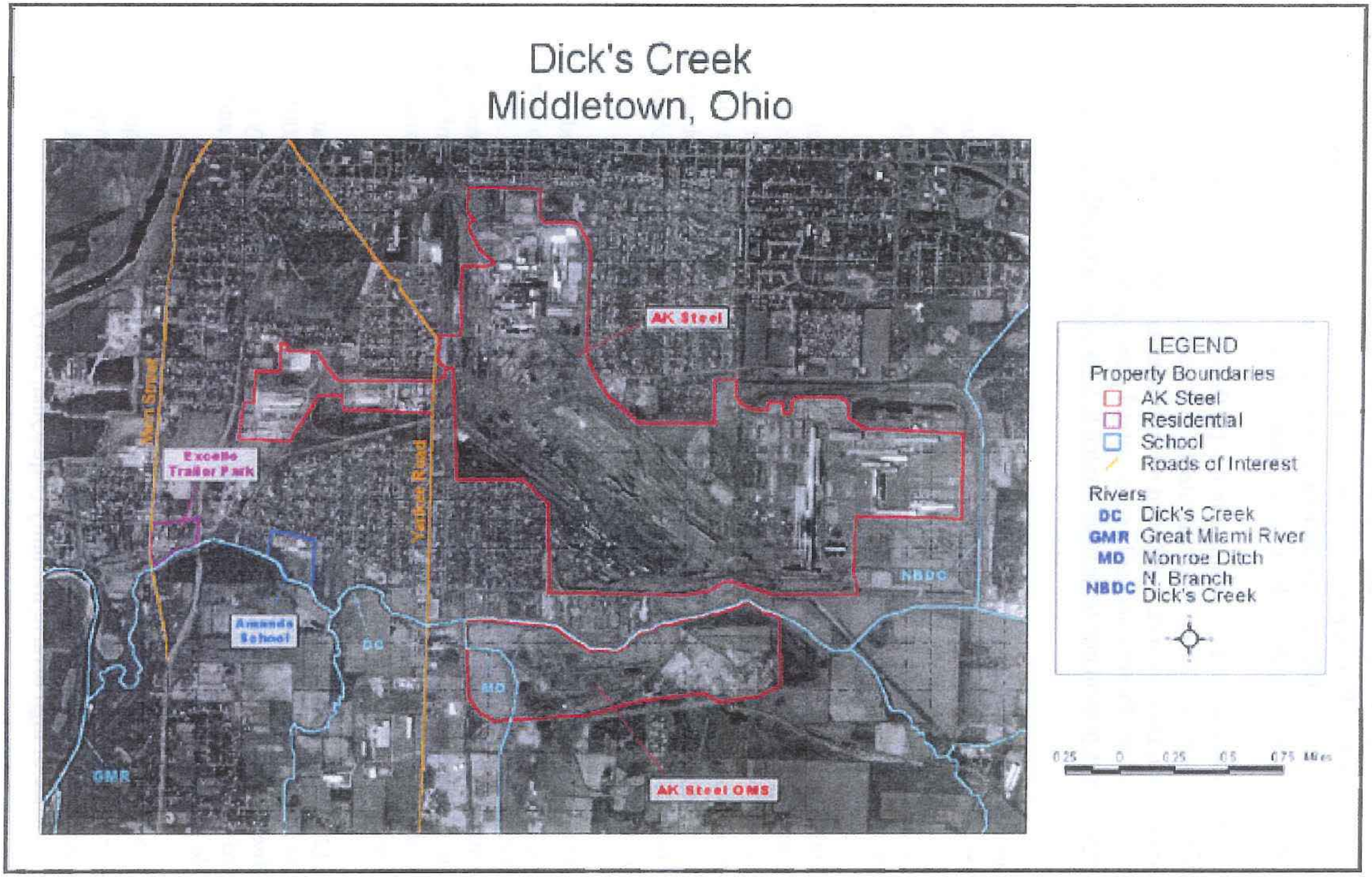

Figure 2-2. Aerial photograph of Middletown, Ohio, with Dick's Creek and Monroe Ditch (light blue), the AK Steel site (red), and other features identified.

- Dick's Creek has a natural stream channel from approximately 100 meters west of Yankee Road Bridge to 200 meters east of the Main Street Bridge, and from approximately 150 meters west of Main Street Bridge to the confluence with Great Miami River (Arcadis, 2001a). Within non-channelized portions of Dick's Creek, there is woody riparian habitat including large deciduous trees, and herbaceous vegetation, small trees and shrubs comprising the understory (Arcadis, 2001a).

- Portions of Dick's Creek were channelized in the 1960s, with the majority of the channelized portion in proximity to the AK Steel site (Arcadis, 2001a). Within the channelized portion, Dick's Creek is buffered by approximately 50 to 75 feet of dense herbaceous vegetation. Pioneer and early successional plant species dominate with a narrow rows of trees present and large trees limited to tops of stream banks (Arcadis, 2001a).

- Large grained sediments (e.g., sand) dominate in Dick's Creek, and the sediment bottom was observed to be unstable (AquaQual, 2001). A fine layer of small grain sediment (e.g., clay, silt, organic matter) settles on most sediment surfaces (AquaQual, 2001). High flows are frequent in Dick's Creek following rain events, and high turbidity occurs during high flows (AquaQual, 2001).

- Arcadis (2001a) noted the following: (1) muskrat dens had been observed at Dick's Creek, particularly along the channelized portion of the creek; (2) raccoon tracks were observed in the channelized areas of Dick's Creek; (3) shoreline vegetated cover along non-channelized areas may support mink; (4) belted kingfisher were observed at Dick's Creek, particularly in the channelized portion; (5) great blue herons have been observed in proximity to Dick's Creek; (6) waterfowl, wading birds, and songbirds were observed in the area; and (7) snakes and frogs were evident.

- Arcadis (2001a) reported that 107 invertebrate taxa (e.g., midges, dragonflies and damselflies, beetles, caddisflies, mayflies) and 43 fish species (e.g., minnows, shiners, dace, sunfish, darters, carp, suckers, bass) have been observed in Dick's Creek. A 2000 ecological survey (Attachment D of Arcadis, 2001a) indicated that (1) Dick's Creek had very poor to good habitat in proximity to and downstream of AK Steel; (2) two of these sample locations did not meet biological criteria scores for macroinvertebrates; and (3) all locations met fish criteria (discussed in Section 6.3.2).

- AquaQual (2001) concluded there was a good riparian zone with adequate habitat allowing for a high diversity of birds and small mammals to exist. AquaQual (2001) reported observations of plants, invertebrates, fish, amphibians, turtles, migratory and resident birds (e.g., robin, killdeer, geese, sparrows, mallard, kingfisher, heron), and mammals (e.g., deer, opossum, raccoon).

- AquaQual (2001) considered the Dick's Creek stream habitat to be of adequate quality, but survey results indicated poor quality benthic and fish communities. For example, few species of macroinvertebrates were present, pollution tolerant species dominated, and there was evidence of high bivalve mortality (AquaQual, 2001).

Previous investigations did not identify any special status species or critical habitats in proximity to Dick's Creek (AquaQual, 2001; Arcadis, 2001a).

2.2.3 Site Visit

Dr. Mace Barron conducted a site visit on June 5, 2002 escorted by AK Steel representatives. General observations from the site visit are documented in Appendix D. Site visit observations included:

- Dick's Creek was channelized near Monroe Ditch, and sediments/floodplain soils had filled portions of the former concrete channel. The floodplain consisted of sandy soils and abundant vegetation that would likely support amphibians and wildlife.

- Racoon and deer tracks were evident near the mouth of Monroe Ditch, and a hawk was observed in the riparian area of Dick's Creek.

- Waist-high stream debris was observed on a warning sign on the Dick's Creek floodplain near Monroe Ditch, indicating that the creek was subject to high flows.

- Petroleum contamination (rainbow sheen, odor) was evident in Monroe Ditch sediments at the confluence with Dick's Creek.

- Within the AK Steel site, Monroe Ditch had flowing water with multiple pools and riffles, a well-developed riparian area, and a meandering stream channel. Small birds and dragonflies/damselflies were observed, and several areas of the stream appeared deep enough to support fish. A mallard duck was in Monroe Ditch just upstream of the AK Steel site property.

- Monroe Ditch appeared to have heavy flows at times, as evidenced by waste-high stream debris at the stream bank near large rail road culverts at the south boundary of the AK Steel site.

2.3 Contaminant Sources and Transport Pathways

PCBs, PAHs, metals, and other contaminants have been associated with site operations and spills and have been released to Dick's Creek (e.g., OEPA, 2000d; Arcadis, 2001a). Potential AK Steel sources of contaminants and transport pathways include facility landfills, outfalls, groundwater seeps and discharges into Dick's Creek and Monroe Ditch, surface runoff, and potential releases to the North Branch of Dick's Creek. Monroe Ditch runs north and west through the south portion of the site and is adjacent to landfill and slag processing areas. A groundwater interceptor trench was completed in 1998 on the east side of Monroe Ditch to capture and treat PCB-contaminated groundwater flowing to Monroe Ditch.

All contaminants detected in Dick's Creek sediment, surface water, and biota from the identified data sets are presented in Appendix A, and the potential for significant upstream sources of COCs are discussed in Sections 4 and 6 below. High flows are frequent in Dick's Creek following rain events, and suspended sediment during high flows provides an additional contaminant transport process (AquaQual, 2001). Evidence of past high flows in both Monroe Ditch and Dick's Creek was observed during the site visit (Section 2.2).

2.4 Identification of COCs

COCs were identified through a process of comparing the maximum detected concentrations of analytes in sediment, surface water, and biological tissues (plants, benthic invertebrates, fish) to screening toxicity benchmarks for aquatic and terrestrial organisms and wildlife.

2.4.1 Exposure Point Concentrations

As documented in Appendix A, only data from 1999 or more recent were screened for Dick's Creek and Monroe Ditch because these data were considered to be most representative of current conditions. An exposure point concentration (EPC) was determined from the maximum detected concentration of each analyte in each medium (surface sediment, surface water, surface soil), and/or type of biota (plants, benthic invertebrates, fish) from the following sources:

- Arcadis (2001a, 2001b, 2001c, 2001d, 2002a): plant tissue, benthic invertebrate tissue, fish (whole body), sediment, surface water, and floodplain soil.
- OEPA (2000a, 2000b, 2000c, 2002): fish (whole body), sediment, and surface water.
- USEPA (1999b, 2003a, 2003b): fish (fillet), sediment, and floodplain soil.

A variety of data sources were used to ensure a comprehensive evaluation because different analytes and analytical methods were utilized for the various sampling and analysis activities in Dick's Creek.

EPCs for total PCBs were determined from the reported total PCB concentrations (e.g., reported sum of PCB homolog groups or Aroclors). PCB and total PAH (tPAH) concentrations in sediment were normalized to 1% OC prior to screening of risks to benthic invertebrates because the selected sediment screening values (SVs) are applicable to sediment with approximately 1% OC (MacDonald et al., 2000a). The OC content of sediment is known to be a controlling factor in sediment accumulation of hydrophobic contaminants, as well as the toxicity to benthic invertebrates. OC normalization is a routine practice in ecotoxicology because it adjusts contaminant concentrations of varying OC content to a single normalized level for interpreting toxicity to benthic organisms. If available, maximum dissolved concentrations of metals were used rather than maximum total concentrations because the dissolved form of metals is most associated with toxicity in aquatic organisms (EPA, 2002).

EPCs were calculated only for detected contaminants, which is reasonable given the broad range of analytes and large number of samples in sediments and surface water. EPCs for wildlife (prey concentrations) were determined using measured, rather than estimated concentrations, with the only exception being terrestrial wildlife exposures to PCBs. PCB concentrations were estimated in terrestrial prey organisms (i.e., earthworms, small mammals) using maximum detected surface soil concentrations (0 to less than 2 feet) because data for terrestrial biota were not available. Only surface soil data were used because of the standard assumption in ERAs that most biota are not currently exposed to subsurface soil contaminants. As shown in Table A6 (Appendix A), PCB concentrations in wildlife prey were estimated using soil to prey bioaccumulation factors (BAFs) to convert dry weight soil and sediment concentrations to wet weight prey concentrations.

2.4.2 Screening Values

An SV for each analyte and media/biota was determined for comparison to the EPC (Section 2.4.3). SVs were determined from the following sources:

- Wildlife Dietary Benchmarks. The lowest of the LOAEL wildlife ingestion benchmarks (mg/kg diet) in Sample et al. (1996) was used to separately screen EPCs determined in plants, invertebrates, and fish. Also, tPAH ingestion SVs were derived in Appendix C because (1) PAH exposure and toxicity occur as mixtures, and (2) appropriate tPAH benchmarks for birds and mammals were not available in Sample et al (1996). LOAEL values were selected rather than NOAEL values to focus the ERA on only those contaminants, receptors, and pathways likely to pose risk. This procedure was considered to be adequately conservative because maximum concentrations were screened, and the lowest LOAEL value in Sample et al. (1996) was used.

- Sediment. Consensus-based probable effect concentrations were from MacDonald et al. (2000a); the lowest freshwater SV from NOAA (1999) was used if a MacDonald et al. (2000a) SV was not available for an analyte. Probable effect concentrations rather than threshold effect concentrations were selected to focus the ERA on only those contaminants likely to pose risk.

- Surface Water. Chronic AWQC were used as the SV when available because they are derived to be protective of chronic exposures to a variety of aquatic species. The lowest value reported by Suter (1996) was used for a chemical if an AWQC value was not available.

- Floodplain soil. Ecological data quality levels (EDQLs; USEPA, 1999a) were used as the SV for floodplain soil. Soil EDQLs are NOAELs that consider toxicity to soil invertebrates and terrestrial wildlife from food chain exposures. The EDQLs (USEPA, 1999a) provide a comprehensive list of NOAEL screening values, but LOAELs are not listed.

2.4.3 Screening-Level Risk Calculations

A hazard quotient (HQ) was determined from the ratio of the EPC and SV (HQ = EPC/SV) for all detected chemicals in each media (surface sediment, surface water, surface soil) and biota type (aquatic plants and invertebrates, fish). With only a few exceptions, all analytes with an HQ greater than one were considered a COC in that media or biota type:

- Sediment. PCBs were the only COC identified in sediment. Three chemicals were identified as COPCs based on an absence of screening values (2,4,6-tribromophenol, 2-fluorobiphenyl, 2-fluorophenol).

- Surface water. No COCs were identified in surface water. PCBs may be COCs in surface water, but high detection limits used in surface water samples did not allow a definitive determination.

- Floodplain Soil. PCBs were the only COC identified. Eleven inorganic chemicals were identified as COPCs based on exceedences of NOAEL levels.

- Aquatic Plants. No COCs were identified in aquatic plants.

- Benthic Invertebrates. PCBs were the only COC identified in benthic invertebrates.

- Fish. PCBs were the only COC identified in fish.

The screening results are presented in Appendix A, including the rationale for excluding any chemicals as COCs. PCBs are addressed quantitatively in the BERA as the only COC for specific receptors and pathways, as shown in Table 2.1. COPCs are addressed qualitatively in Section 6 of the BERA.

Table 2.1. Summary of Screening Results for Contaminants of Concern			
Receptor	**Pathway**	**COC**	**Confidence in Results[1]**
Benthic invertebrates	Contact with sediment	PCBs	High confidence: large analyte and sample database. Three sediment COPCs identified.
Fish, other aquatic organisms	Contact with surface water	none[3]	High confidence: large analyte and sample database.[2]
Herbivorous wildlife	Ingestion of plants	none	Moderate confidence: limited samples and analytes
Piscivorous wildlife	Ingestion of benthic invertebrates	PCBs	Moderate confidence: limited samples and analytes
	Ingestion of fish	PCBs	Moderate confidence: limited samples and analytes
Terrestrial invertebrates, plants	Contact with floodplain soil	none	Moderate confidence: eleven soil COPCs identified.
Terrestrial wildlife	Ingestion of soil invertebrates and small mammals	PCBs	Moderate confidence: determined using modeled PCB concentrations in prey. Eleven soil COPCs identified.

1. Confidence in results based on consideration of number of samples, number of analytes, and spatial extent of contamination characterization (e.g., localized or spatially extensive sampling).
2. Aquatic plants not considered to be a risk because of apparent low sensitivity, as evidenced by high PCB bioaccumulation in algae without apparent adverse effects (Stange and Swackhamer, 1994). Relatively low tissue concentrations were accumulated in Dick's Creek aquatic plants compared to fish and benthic invertebrates (Arcadis, 2001a). See Table A1 (Appendix A).
3. PCBs may be COCs in surface water, but high detection limits used in surface water samples did not allow a definitive determination.

2.5 Ecological Exposure and Effects

PCBs were identified as the only COC in the Dick's Creek system and were also considered the principal COC in both of the previous ERAs (AquaQual, 2001; Arcadis, 2001a). Other contaminants, including PAHs and metals, are present in Dick's Creek and may be elevated from releases from the AK Steel site. However, based on the comprehensive risk screening in this problem formulation (Section 2.4), only PCBs are quantitatively evaluated in the BERA for those receptors and pathways identified in Table 2.1.

PCBs are known to be persistent, bioaccumulative, and highly toxic to aquatic organisms and wildlife (Eisler, 1986; Barron et al., 1994, 1995, 1996; van Wezel et al., 1999; Monosson, 1999/2000; USEPA, 2000; RETEC, 2002). For example, chronic exposure of PCBs in fish can cause reproductive impairment, developmental toxicity in embryos (malformations, reduced survival), reduced larval survival, tumor promotion, immunotoxicity, liver damage, endocrine disruption, included reduced gonadal growth, and altered steroid hormone concentrations (Monosson, 1999/2000; Barron et al., 2000). In birds and mammals, chronic exposure to PCBs can impair fertility, induce malformations, reduce the number of viable offspring, cause premature death of offspring, and impair the behavior and immune status of adults (Barron et al., 1995; Eisler and Belisle, 1996; Brunstrom et al., 2001; Fernie et al., 2001; RETEC, 2002). As discussed in Section 4 and 5, PCBs occur as complex mixtures of individual congeners including some congeners that cause dioxin-like toxicity (Barron et al., 1994; Eisler and Belisle, 1996). PCB exposure is quantitatively evaluated in Sections 4, and Section 5 presents TRVs for PCBs in Dick's Creek sediment, surface water, and wildlife diets.

2.6 Endpoint Selection and Conceptual Model Description

The assessment endpoints, measurement endpoints, risk questions, and conceptual site model (CSM) for the Dick's Creek system are discussed in this section and are summarized in Table 2.2. Assessment endpoints are explicit expressions of the actual environmental values that are to be protected (USEPA, 1998), and define the focus of the BERA by identifying ecological receptors and potential risk pathways (e.g., water contact to fish, dietary exposure of wildlife). Three criteria were used to select assessment endpoints: ecological relevance, susceptibility to known stressors (e.g., sensitivity to and mode of action of toxic effects, likelihood of high exposure), and relevance to management goals (e.g., ecological or recreational importance, pathway to other important receptors).

Table 2.2 lists the assessment endpoints selected for the BERA, which are focused on the survival, growth, and reproduction of aquatic organisms and wildlife because laboratory and field studies have shown that PCBs can impact these endpoints.

Measurement endpoints (measures of effect) are specific metrics that can be quantified to determine the adverse effects of contaminants. Measurement endpoints are listed in Table 2.2 for each category of ecological receptor, and include a comparison of media concentrations to TRVs and comparison of ingested doses of PCBs to TRVs for wildlife. These endpoints were selected because they allow a quantitative assessment of risks to aquatic and terrestrial invertebrates, wildlife, and fish. The selected TRVs used in evaluating the measurement endpoints are described in Section 5, and are based on those effects most likely to impact populations: survival, growth, and reproduction. Additional information that was used qualitatively in the weight-of-evidence evaluation included significant toxicity in aquatic toxicity bioassays and impairment of ecological health determined from ecological surveys. The risks of dioxin-like PCB congeners in the Dick's Creek system are also considered in the weight-of-evidence evaluation, consistent with USEPA (2003c).

Table 2.2. Assessment and Measurement Endpoints and Risk Questions for PCB Exposure Pathways and Receptors Identified in Table 2.1			
Receptor Category	**Assessment Endpoint**	**Measurement Endpoint**	**Risk Question**
Benthic invertebrates	Survival, growth, and reproduction of benthic invertebrate communities	Comparison of sediment concentrations of PCBs to sediment toxicity benchmarks	Are PCBs in sediments causing risks to benthic invertebrates?
		Qualitative evaluation of site-specific toxicity tests	
		Qualitative evaluation of benthic invertebrate community indices at reference and site areas	
Fish and water column invertebrates	Survival, growth, and reproduction of aquatic organisms	Comparison of surface water concentrations of PCBs to AWQC[1]	Are PCBs in surface water causing risks to fish and water column invertebrates?
		Comparison of fish tissue concentrations of PCBs to tissue residue benchmarks	
Piscivorous wildlife	Survival, growth, and reproduction of piscivorous wildlife	Comparison of ingested doses of PCBs to dietary toxicity benchmarks for raccoons, mink, and kingfishers	Are PCBs in aquatic prey causing risks to piscivorous wildlife?
Terrestrial wildlife	Survival, growth, and reproduction of terrestrial wildlife	Comparison of ingested doses of PCBs to dietary toxicity benchmarks for robins and kestrels	Are PCBs in floodplain prey causing risks to terrestrial wildlife?
1. AWQC: Ambient water quality criteria based on bioaccumulation in fish tissue and wildlife toxicity.			

A CSM is a written description and visual representation of predicted relationships between ecological entities (i.e., receptors) and stressors (e.g., PCBs), and consists of two primary components: risk hypotheses and a model diagram (USEPA, 1998). Figure 2.3 presents the CSM, which shows site sources of PCBs (e.g., outfalls, Monroe Ditch), transport pathways (e.g., groundwater discharge), receptors (e.g., fish, wildlife), and exposure routes (e.g., benthic invertebrate contact with sediment; wildlife ingestion of fish) that are quantitatively evaluated in the BERA.

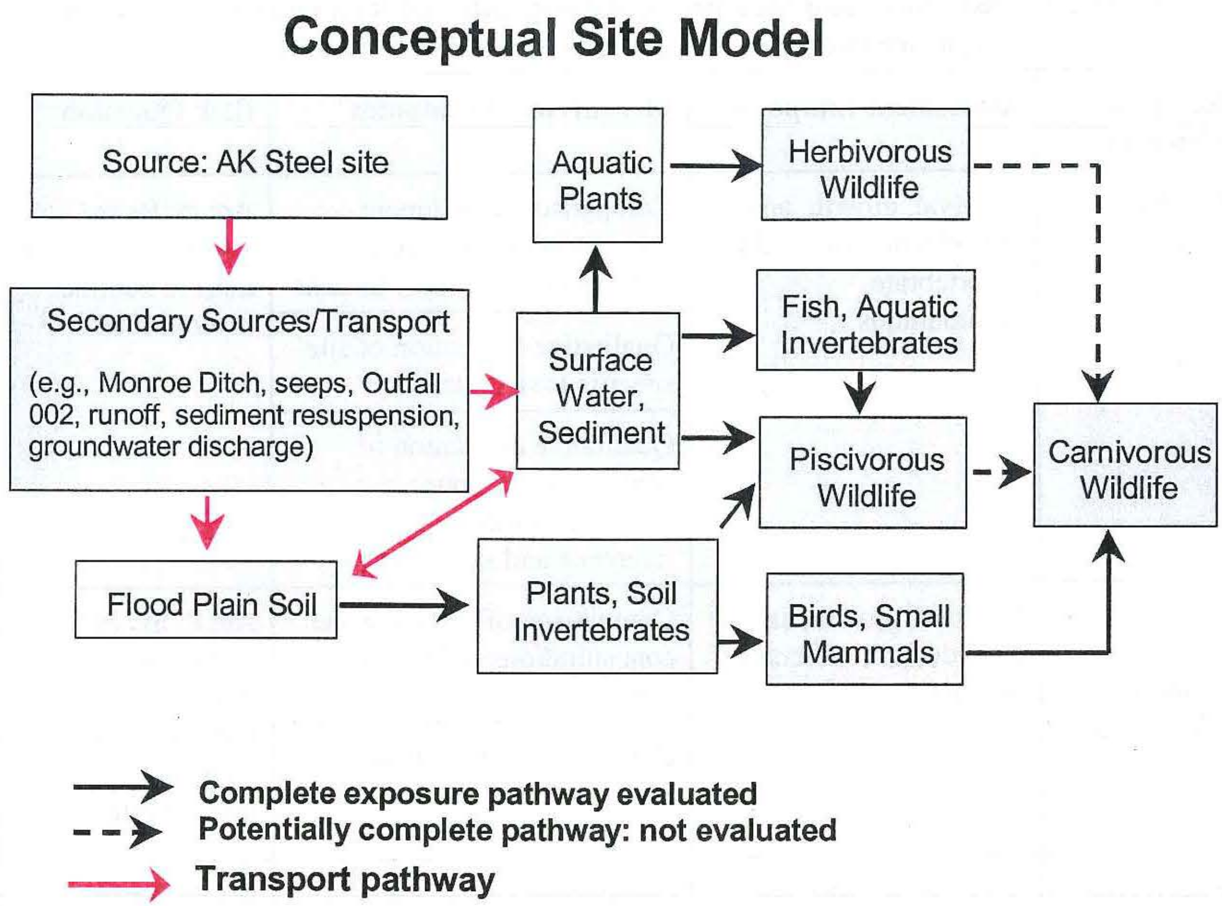

Figure 2.3. Conceptual site model showing exposure pathways evaluated for PCB risks to ecological receptors (block solid arrows), and PCB transport pathways (red arrows).

The wildlife receptors that are quantitatively assessed in this BERA are the raccoon, mink, belted kingfisher, robin, and American kestrel. As discussed in Sections 4 and 5, these species were selected because they are highly exposed (e.g., consume contaminated media and biota, have relatively small home ranges), are sensitive to PCBs (particularly mink), and exposure parameters and TRVs are available (USEPA, 1993; USEPA, 2000).

Risk hypotheses are specific assumptions about potential risk to assessment endpoints (USEPA, 1998), and are used to generate a risk question for each ecological receptor in Table 2.2. Each risk question is specifically evaluated in Section 7 of the BERA based on a weight-of-evidence assessment. Pathways, receptors, and chemicals (COPCs) that are not quantitatively evaluated are qualitatively evaluated in the uncertainty analysis (Section 6.4)

2.7 Scientific/Management Decision Point

2.7.1 Risk Management Considerations

USEPA Region 5 requires an objective, quantitative, and comprehensive assessment of ecological risks that incorporates all available information and data in a weight-of-evidence evaluation for the Dick's Creek system. As discussed in Section 6, a probabilistic assessment was used to quantify risks of PCBs because this approach incorporates uncertainty in exposure and toxicity, and presents a probability of exceeding a risk threshold that can be readily interpreted by risk managers (USEPA, 1999a). To the extent possible, COCs were identified by screening maximum chemical concentrations against LOAEL TRVs, rather than NOAELs. NOAELs are most appropriate for identifying COPCs in a SERA, rather than for the identification of COCs needed in a BERA. NOAELs are also appropriate for assessing risks to special status species and critical habitats, but there has been no apparent identification of any threatened and endangered species, critical habitats, or species of special concern in the Dick's Creek system. LOAEL TRVs were preferentially selected rather than NOAELs to eliminate COPCs that were unlikely to significantly contribute to site risks. NOAELs were used in screening some contaminants in floodplain soil, and a chemical was considered to be a COPC if its maximum concentration exceeded the NOAEL. COPCs are discussed qualitatively in the uncertainty section of the BERA.

2.7.2 Decision to Proceed to a BERA

The initial risk screening was performed in this Problem Formulation section and corresponded to Step 3 of the USEPA (1997) ecological risk assessment process. A screening-level ERA [Steps 1 and 2 of the USEPA (1997) risk process] was not performed because the potential for ecological risks had already been identified in the Arcadis (2001a) and AquaQual (2001) risk assessments.

PCBs were the only COC identified in the problem formulation, and aquatic organisms and wildlife were determined to be at potential risk from PCBs. A BERA is required to quantitatively determine the risks of PCBs in the Dick's Creek system. The following sections of the BERA quantitatively assess PCB risks according to current USEPA (1997; 1998; 2001) guidance.

3. Data Used in the BERA

3.1 Overview

Only data collected since 1999 were used in the BERA because they were considered to be most representative of current conditions. Data were obtained from three sources: AK Steel (Section 3.2), OEPA (Section 3.3), and USEPA (Section 3.4). Additionally, bioassay and ecological survey results from AquaQual (2001) are used qualitatively in the weight-of-evidence and uncertainty analysis of the BERA (Section 6). These data include in-situ bioassays performed in 1999 and 2000, and an ecological survey performed in 2000. Only data made available to Dr. Barron prior to September 1, 2003 were included in the BERA.

3.2 AK Steel Data

AK Steel data quantitatively used in assessing ecological risks consisted of information provided in the following documents:

- Arcadis. 2002a. *Floodplain Soil and Supplemental Sediment Sampling and Analysis Plan.* Arcadis G&M, Inc. Prepared for AK Steel Corp. February 13, 2002.

- Arcadis. 2001a. *Ecological Risk Assessment for Dick's Creek.* Arcadis G&M, Inc. Prepared for AK Steel Corp. June 1, 2001.

- Arcadis. 2001b. *Addendum 1 to the Ecological Risk Assessment for Dick's Creek, PCBs in Surface Versus Subsurface Sediments.* Arcadis G&M, Inc. Prepared for AK Steel Corp. July 10, 2001.

- Arcadis. 2001c. *Addendum 2 to Ecological Risk Assessment: Background Risks.* Arcadis G&M, Inc. Prepared for AK Steel Corp. July 11, 2001.

- Arcadis. 2001d. Data Summary Report: Sediment and Surface Water (18 Dec. 2000 - 2 Feb. 2001). Arcadis G&M, Inc. Prepared for AK Steel Corp. April 26, 2001.

Data included PCB concentrations in sediment, surface water, seeps, floodplain soil, aquatic plants, benthic invertebrates, and fish collected in 1999 and 2000. AK Steel data are described in Section 4.

3.3 OEPA Data

Data used in the BERA included PCB concentrations in sediment, surface water, seeps, and fish samples collected in 2000, and fish samples collected in 2002. These data are described in Section 4. OEPA data quantitatively used in assessing ecological risks consisted of information in the following documents:

- OEPA. 2000a. *Laboratory Organic Analysis Data Reports.* Ohio EPA [sediment samples collected August 2000].

- OEPA. 2000b. *Laboratory Organic Analysis Data Reports, Laboratory Inorganic Analysis Data Reports, and Tissue Sample Submission Forms.* Ohio EPA [fish samples collected November 2000].

- OEPA. 2000c. *Laboratory Organic Analysis Data Reports, and Laboratory Inorganic Analysis Data Reports.* Ohio EPA [water samples collected July to September 2000].

- OEPA. 2002. PCB Analysis of the Fish Tissue from Whole Body Samples Collected from Dick's Creek in Bulter County, Ohio During July 10-11, 2002. September 30, 2002 Letter of Transmittal and Data Reports from D. Zimmerman, Ohio EPA, Dayton, Ohio.

Seep data were considered in the ERA as a source of PCBs in the Dick's Creek system:

- OEPA. 2001. *Ohio EPA Summary of AK Steel Seeps Found During Deep Inspections Starting November 2000 - October 2001, per USEPA 7003 Order.* Ohio EPA data sheets.

OEPA data used in the BERA are described in Section 4.

3.4 USEPA Data

USEPA data quantitatively used in assessing ecological risks consisted of information in the following documents:

- USEPA. 1999b. *Joint Sampling Project, AK Steel Middletown, Ohio, June 2, 1999* [sediment and water samples collected by OEPA on June 2, 1999; only PCB data used].

- USEPA. 2003a. *Field & Laboratory Data Report, Physical and Chemical Characterization of Dick's Creek and Associated Flood Plain, Middletown, Ohio.* U.S. Environmental Protection Agency. July 2003.

- USEPA. 2003b. *Data Validation Report for Fish Samples from Dick's Creek, Middletown, OH* (Prepared by Booz Allen Hamilton. April 8, 2003). *Fish tissue Data Tables.* [August 25, 2003 transmitted data files: TotalPCBCongeners.Table.wpd, STL.OEPA2002.FishCongenerdata.Final.xls]

USEPA data used in the BERA are described in Section 4.

4. Exposure Analysis

4.1 Overview

PCBs were produced as commercial mixtures (e.g., Aroclors) of a hundred or more individual polychlorinated biphenyl congeners (Eisler, 1986). The environmental fate, exposure, and toxicity of PCBs can be dependent on the congener composition of the PCB mixture, and some PCB congeners can cause dioxin-like toxicity at substantially lower levels than total PCB concentrations (Barron et al., 1994; Eisler and Belisle, 1996). The congener composition of a commercial PCB mixture will change once it enters the environment because of differential partitioning, degradation, and bioaccumulation of the PCB congener components of the mixture.

On a homolog basis (i.e., sum of PCB congeners with the same number of chlorine atoms), PCBs in Dick's Creek sediment appear to generally resemble Aroclor 1242, but also contain higher chlorinated congeners (Figure 4.1). The homolog composition of PCBs in benthic invertebrates and fish appear to resemble Aroclor 1248 more than Aroclor 1242, which may be caused by environmental and biological processes. For example, Figure 4.1 shows that fish contained a greater proportion of PCBs containing four and five chlorines than did sediment. Figure 4.2 shows example results of recent congener-specific analysis of PCBs in sediment and large fish fillets (USEPA, 2003a, 2003b). Figure 4.2 also indicates that sediments generally contain lower chlorinated PCB congeners than fish, which is consistent with selective congener degradation and bioaccumulation (Butcher et al., 1997). Section 4.11 below discusses statistical fingerprinting of PCBs in the Dick's Creek system.

The majority of exposure data applicable to the BERA are total PCB data. These data consist of measures of total PCB concentrations in media (surface water, surficial sediment and floodplain soil), and biological tissues (aquatic plants, invertebrates, and fish). Total PCB data for the Dick's Creek system were reported based on one of three approaches: (1) by summing the concentrations of PCBs that were reported as detected commercial Aroclor mixtures, (2) by summing the PCBs reported in each homolog group, or (3) by summing the concentrations of all detected congeners. Total PCB data are important and relevant to the BERA because they are spatially and temporally extensive and ecotoxicity values for total PCBs are available for a variety of species and exposure media.

In addition to the total PCB data, exposure data are available for specific PCB congeners known as the dioxin-like PCBs. These congeners have high toxicity to both fish and wildlife because they can exhibit a planar molecular configuration that confers dioxin-like toxicity at very low concentrations (discussed in Section 5). Additionally, they can act additively relative to the potency of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). As discussed in Section 4.7 below, dioxin-like PCB data applicable to the BERA are more limited but are important because dioxin-like PCB congener risks may exceed risks determined from total PCBs (USEPA, 2003c). Greater toxicity of environmental concentrations of dioxin-like PCBs can occur because of greater persistence and bioaccumulation, resulting in enrichment of the these congeners relative to their concentration in the original Aroclor (Barron et al., 1994; Leonards et al., 1997).

4.2 Section Organization

This Section summarizes the use of total PCB and dioxin-like congener data in the BERA. Table 4.1 provides summary statistics for the total PCB data. Total PCB concentrations in sediment (Section 4.3), surface water (Section 4.4), floodplain soil (Section 4.5), and biota tissues (Section 4.6) are described below, and in the tabular summaries of Appendix F. Section 4.7 summarizes the dioxin-like congener data used in the BERA, and Appendix G describes the approach used to extrapolate congener concentrations in fish fillets to whole body and fish embryo concentrations. Section 4.8 provides the methodology and parameters used in modeling wildlife ingestion; Section 4.9 discusses background levels of PCBs in Dick's Creek; Section 4.10 summarizes trends in PCB exposure, and Section 4.11 below discusses statistical fingerprinting of PCBs in the Dick's Creek system.

4.3 Total PCBs in Sediment

Two comprehensive data sets of total PCBs in surface sediments (e.g., 0 to a maximum of 1 foot depth) were compiled from the available reports with 1999 or more recent sediment sampling results for Dick's Creek and Monroe Ditch. As specified in Section 3 and Appendix F, total PCB data were available from multiple Arcadis, OEPA, and USEPA information sources:

(1) Total PCB concentrations in surface sediment (mg/kg dw) were obtained from OEPA, USEPA, and Arcadis reports as detailed in Section 3. A combined Dick's Creek and Monroe Ditch surface sediment data set was used in assessing risks to wildlife from incidental sediment ingestion. Exposure point concentrations were derived from a log normal distribution of total PCB concentrations in surface sediments (Table 4.1).

(2) In addition to the "as reported" sediment concentrations, each total PCB concentration in sediment was normalized to the sample-specific OC content of the sediment for screening of risks to benthic invertebrates. Specifically, total PCB concentrations in sediment (mg/kg dw) were divided by the reported percentage of OC to provide a data set of sediment PCB concentrations normalized to 1% sediment OC (mg/kg 1% OC). If OC results were not provided for a specific sediment sample, then the sediment PCB concentration for that sample was not included in the OC normalized data set. As discussed above, OC normalization is a standard practice in ecological risk assessment and ecotoxicology because it reduces variability in sediment PCB concentrations caused by variability in sediment OC. The 1% OC normalization appears most applicable for comparing environmental concentrations of PCBs in sediment to sediment ecotoxicity screening values. The combined Dick's Creek and Monroe ditch surface sediment 1% OC data set was used to assess risks to benthic invertebrates. Exposure point concentrations were derived from a lognormal distribution of OC normalized total PCB concentrations in surface sediments (Table 4.1).

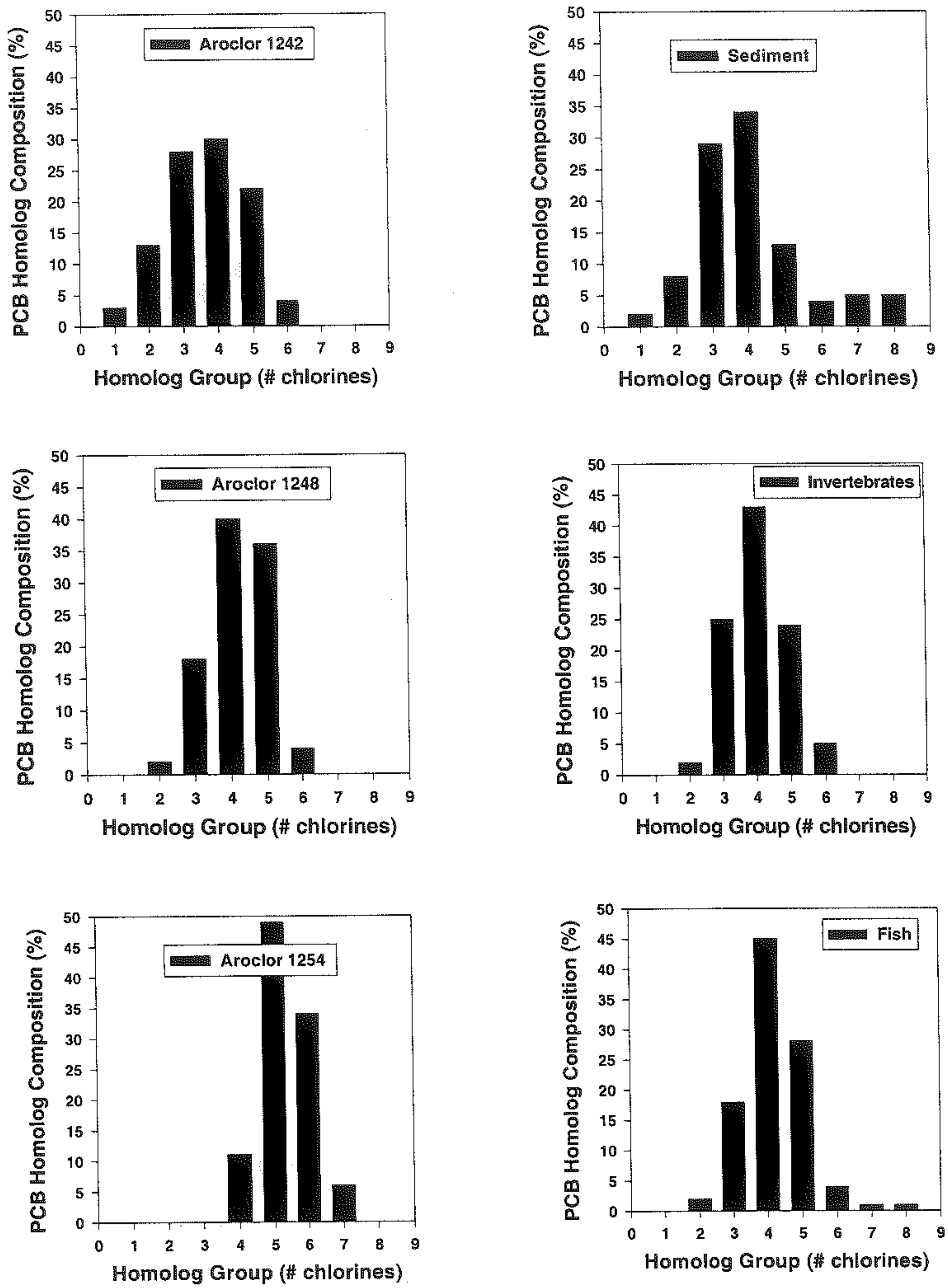

Figure 4.1. PCB homolog composition in commercial Aroclor mixtures and Dick's Creek sediment, invertebrates, and fish. Data source: Arcadis (2001a; Table 4-7).

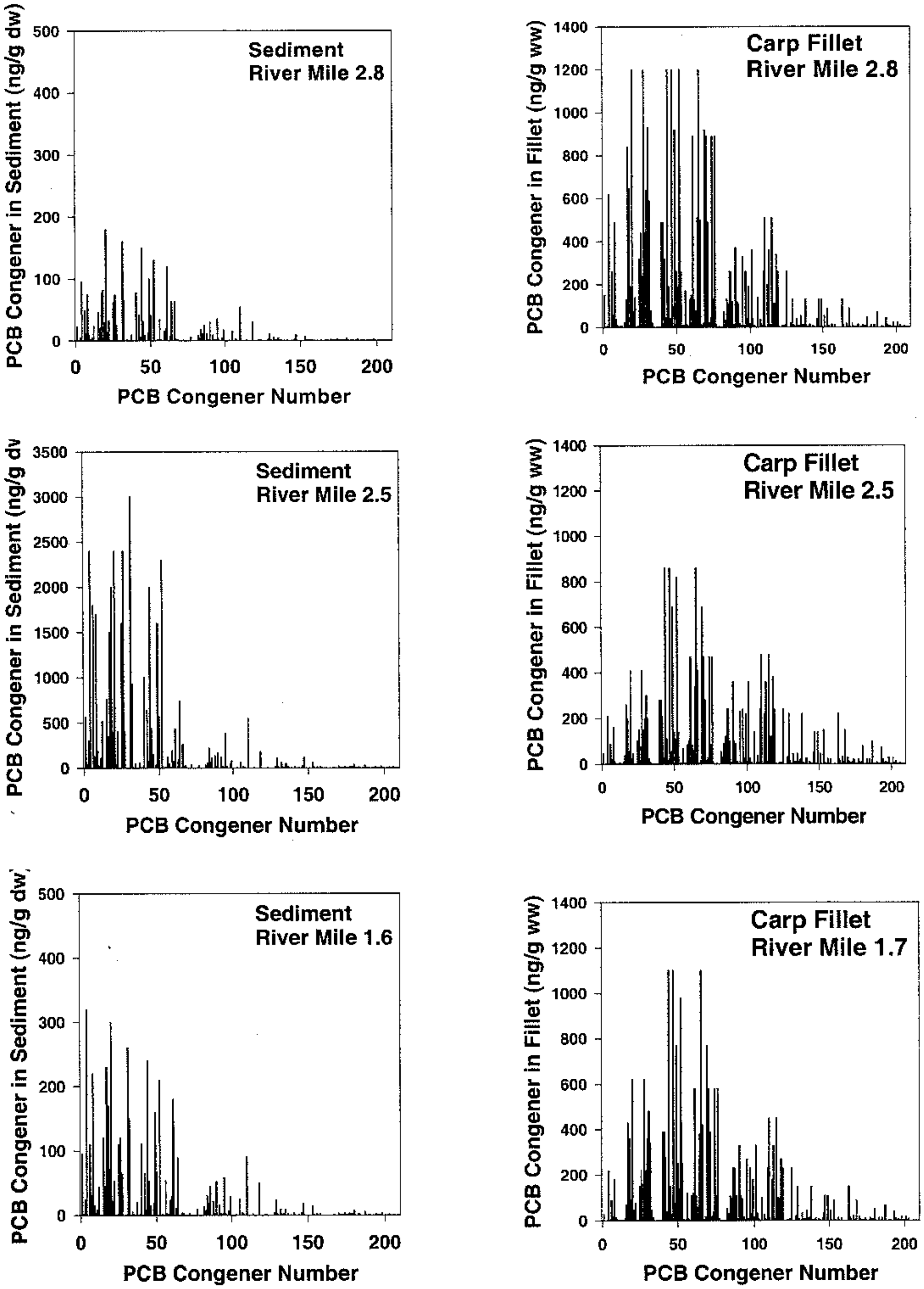

Figure 4.2. PCB congeners in selected sediment and carp fish fillet samples from USEPA (2003a, 2003b).

Table 4.1. Total PCB Exposure Data and Probability Distribution Functions Used in Risk Calculations					
Media/Biota	Units	Total PCBs[1]			
		Mean (SD)	Min-Max	n	Distribution
Sediment (total)[2]	mg/kg dw	3.83 (8.07)	0 - 48.2	61	lognormal
Sediment (1% OC)[3]	mg/kg dw	2.75 (6.55)	0 - 33.2	59	lognormal
Surface water[4]	mg/L	NC[4]	0	5	NC[4]
Invertebrate[5]	mg/kg ww	0.560 (0.837)	0.098 - 2.46	8	lognormal
Fish (≤ 14 cm)[6]	mg/kg ww	3.54 (2.14)	0.656 - 9.32	20	lognormal
Small-medium[7] fish	mg/kg ww	3.94 (2.26)	0.656 - 9.32	26	lognormal
All fish[8]	mg/kg ww	4.31 (3.25)	0.569 - 17.1	38	lognormal
Floodplain soil[9]	mg/kg dw	4.22 (11.1)	0 - 39.2	12	lognormal

1. SD: standard deviation; Min-Max: minimum-maximum values; n: sample size; Distribution: probability distribution used in assessing ecological risks. Data are listed in Appendix F and exclude background sample data.
2. Used in assessing wildlife risks from incidental sediment ingestion. Includes data from Monroe Ditch and Dick's Creek.
3. Normalized to 1% OC; used in assessing risks to benthic invertebrates. Includes data from Monroe Ditch and Dick's Creek.
4. A value of 0 mg/L PCBs was used as surface water concentration in the BERA. Recent surface water results within Dick's Creek are non-detects with elevated detection limits (e.g., 0.0001 mg/L). PCBs have been detected in seeps discharging groundwater from the AK Steel site into Monroe Ditch and Dick's Creek.
5. Used in assessing wildlife risks from ingestion of benthic invertebrates.
6. Whole body fish data used in assessing risks to kingfishers.
7. Whole body fish data used in assessing risks to mink and raccoons (excludes large fish species: e.g., carp, bass, bullhead, sucker).
8. Whole body fish data used in assessing risks to fish from accumulation of critical body residues.
9. Used to estimate PCB concentrations in earthworms and small mammals using parameters specified in Table A6.

Figure 4.3 shows low concentrations of PCBs in Dick's Creek surface sediment upstream of the AK Steel site and apparent facility source areas such as Monroe Ditch and Outfall 002. Figure 4.3 also shows that PCBs substantially increase downstream of these source areas beginning at approximately Dick's Creek river mile 3. The highest concentrations of sediment PCBs measured in the Dick's Creek system are in proximity to apparent facility source areas.

PCBs are also present in subsurface sediments (e.g., > 1 foot depth) of Dick's Creek downstream of apparent facility source areas, with concentrations of buried PCBs as high as 92 mg/kg (USEPA, 2003a). Subsurface PCB data were not used in the BERA because surface sediment concentrations are considered the most relevant to assessing risks to both aquatic organisms and wildlife. However, subsurface PCBs may represent a substantial source of PCBs to Dick's Creek. Subsurface PCBs may become incorporated into surface sediments and become available for bioaccumulation and toxicity to aquatic organisms and wildlife through resuspension, flood events, and deposition.

PCBs are also present in the floodplain soils of Dick's Creek downstream of apparent facility source areas, and represent an additional source of PCBs to the Dick's Creek system. PCBs in floodplain soils are discussed in Section 4.5.

4.4 Total PCBs in Surface Water

Surface water data for PCBs that are adequate for the BERA were not available from the chemistry data sources used in the risk assessment (Section 3). These samples have been analyzed using elevated detection limits (e.g., 0.2 μg/L) relative to chronic AWQC (0.014 μg/L), and includes PCB surface water data reported by OEPA (2000c) and Arcadis (2001a) that were all non-detected values. A value of 0 mg/L PCBs was used as the surface water concentration in the assessment of wildlife risks in the BERA.

PCBs have been detected in seeps discharging groundwater from the AK Steel site into Monroe Ditch and Dick's Creek. Both OEPA (2001) and Arcadis (2002b) have reported PCBs in seeps located on the south bank of Dick's Creek along the AK Steel facility:

- Seep #10: 0.66 to 1.35 μg/L
- Seep #16: south bank 0.3 μg/L
- Seep #22: south bank 0.58 to 0.7 μg/L.

Seeps in Monroe Ditch have also have been reported to contain PCBs (e.g., Seeps #11 and #12: 6.18 to 8.89 μg/L; Arcadis, 2002c).

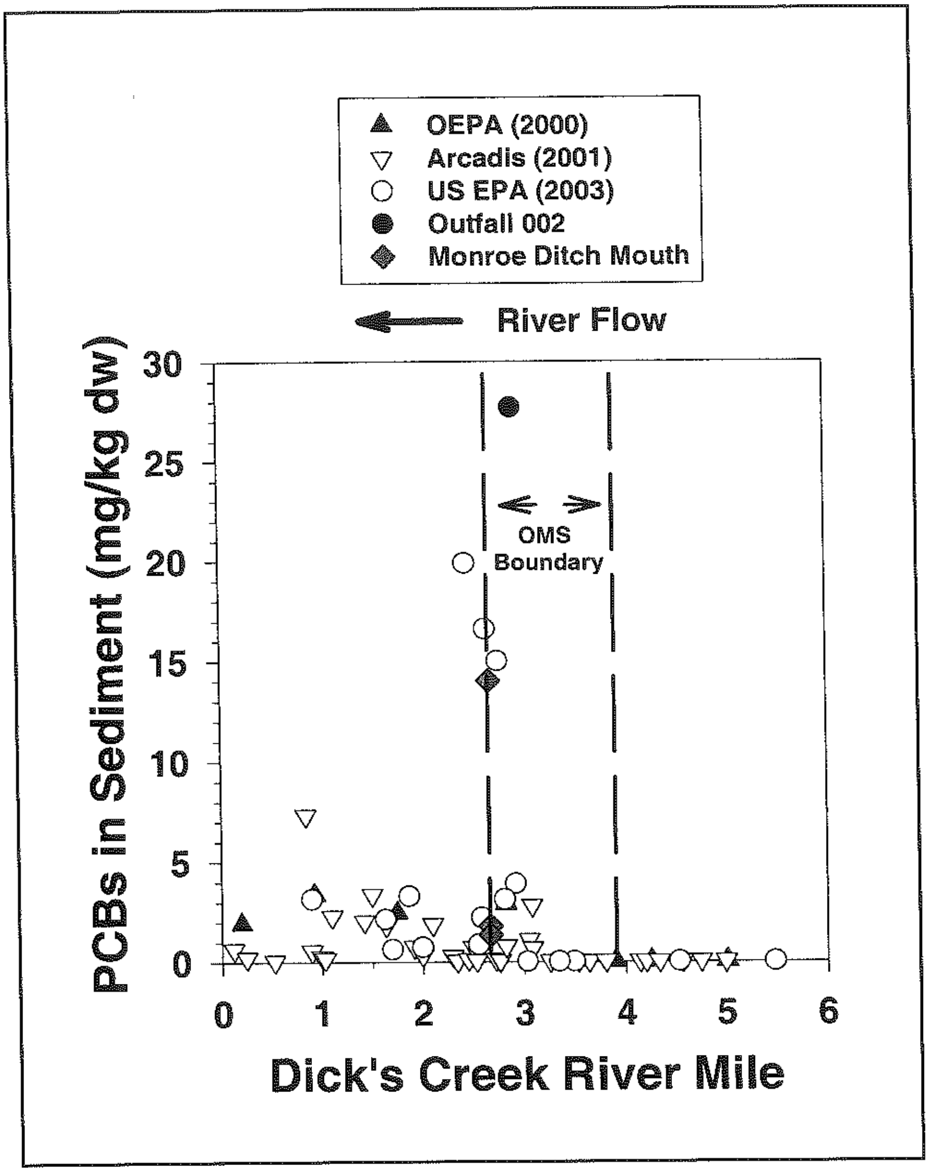

Figure 4.3. Total PCBs in surface sediment of Dick's Creek, Outfall 002, and the Monroe Ditch mouth collected between 1999 and 2003, in relation to the approximate boundary of the AK Steel OMS facility. See Appendix F for PCB data and specific data sources; Monroe Ditch data are near confluence with Dick's Creek (Table F6-1).

4.5 Total PCBs in Floodplain Soil

PCB data collected since 1999 for the floodplain of the Dick's Creek system are relatively limited compared to the spatial and temporal extent of sediment PCB data, with the majority of data from recent USEPA sampling (EPA, 2003a). Only PCBs in surface soil (mg/kg dw) are used in the BERA because surface concentrations are considered the most relevant to assessing risks to terrestrial organisms. Surface soil data included samples collected between zero and two feet by Arcadis (2002a), which had low or non-detected concentrations of PCBs (Table F5-1; Appendix F). Total PCB concentrations as high as 39 mg/kg dw in surface of the Dick's Creek floodplain have recently been reported (EPA, 2003a).

All data used quantitatively in the BERA are presented in Table F5-1 of Appendix F. EPCs were derived from a lognormal distribution of total PCB concentrations in floodplain surface soil (Table 4.1). Floodplain surface soil data were used to quantitatively assess risks to terrestrial wildlife from estimated concentrations in prey species (Section 6). Additionally, floodplain surface soil concentrations of PCBs were used to quantitatively evaluate risks to piscivorous wildlife that may feed on both aquatic and terrestrial prey (Section 6). Maximum floodplain surface soil data (mg/kg dry weight [dw]) were used in determining that there were minimal risks to terrestrial plants and soil invertebrates (Table A6-1; Appendix A), as described in Section 2.

PCBs in the subsurface of the Dick's Creek floodplain represent a potential source of PCBs to both surface soils and sediments. Recent sampling also shows PCBs are in subsurface soil of the Dick's Creek floodplain (e.g., 17 mg/kg EPA, 2003a). PCBs have also been detected at very high levels in subsurface floodplain soil during trenching operations near Monroe Ditch (e.g., 210 mg/kg; AK Steel, 2001). AK Steel (2001) also reported total PCB concentrations of 1.17 mg/L in water infiltrating the trench, which exceeds the water solubility of Aroclor 1242 (240 μg/L; Eisler, 1986). These data indicate that high levels of PCBs are present in the subsurface in proximity to Monroe Ditch. Observations from the June 5, 2002 site visit (Appendix D) indicated that Dick's Creek is subject to high flows and substantial sediment movement as indicated by the width of deposited soil/sediment in the floodplain and the vertical extent of debris on floodplain vegetation (See Appendix D for photographs). This suggests the potential for transport of PCBs between Dick's Creek sediment and its floodplain.

4.6 Total PCBs in Biota

Total PCB concentrations in biota (mg/kg wet weight tissue [ww]) in Dick's Creek have been measured and reported for aquatic plants, benthic invertebrates, and fish. Only sampling results from 1999 or more recent for Dick's Creek were used in the BERA because these data were considered most reflective of current conditions. As specified in Section 3 and Appendix F, total PCB data in biota were available from multiple Arcadis, OEPA, and USEPA sources. Total PCB data in biota are important because they provide a more direct measure of PCB exposure to both fish and wildlife than estimated concentrations. EPCs were derived from the lognormal distributions of total PCB concentrations in biota (Table 4.1).

4.6.1 Aquatic Plants

Table F2 (Appendix F) shows that PCB concentrations in aquatic plants ranged from non-detections (<0.01 mg/kg) to 0.284 mg/kg (ww), and that concentrations were higher in August 2000 than in October 1999 and increased downstream of Outfall 002. The maximum concentration was used in the risk screening (Section 2.4) and indicated herbivorous wildlife were not at risk from total PCBs in aquatic plants (Table A1; Appendix A).

4.6.2 Benthic Invertebrates

Table F3-1 (Appendix F) shows that PCB concentrations in benthic invertebrates ranged from 0.098 to 2.46 mg/kg (ww) in samples collected in 1999 and 2000. Arcadis (2001a) data show non-detectable PCB contamination in invertebrates upstream of Outfall 002 (<0.02 and <0.04 mg/kg).

4.6.3 Fish

Concentrations of PCBs in fish are summarized in Table 4.1 and Appendix F (Tables F4-1, F4-2, F4-3) by the fish size groups used in the BERA as follows:

- **Small fish:** spotfin shiners and other collected fish that were less than 14 cm. PCBs (0.66 - 9.3 mg/kg ww) were used in assessing risks to belted kingfisher because this species feeds on fish of a maximum size of 14 cm. For example, USEPA (1993) noted that kingfishers will feed 13-cm fish to two-week old nestlings. Davis (1982) reported that 6- to 12-cm fish were the dominant size consumed by kingfishers feeding in a southwestern Ohio, but they also consume 12- to 14-cm fish. Scott and Crossman (1973) noted that kingfishers consumed creek chubs, which was one of the medium size fish species included in the database.

- **Small and medium size fish:** Shiners, sunfish and creek chubs that were collected with a maximum size of 18.2 cm. PCBs (0.66 - 9.3 mg/kg ww) were used in assessing risks to mink and raccoon because these species will feed on small and medium size fish.

- **All fish.** This group included all sizes of fish (PCB range of 0.57 - 17.1 mg/kg ww) and was only used in assessing risks to fish from accumulated body residues of PCBs.

Figure 4.4 shows the spatial distribution of PCBs in small (spotfin shiners) and medium (sunfish, chubs) size fish species that can serve as wildlife prey. Figure 4.4 demonstrates that PCBs substantially increase in fish downstream of Outfall 002 and Monroe Ditch. PCBs in these species of fish are generally low in areas upstream of apparent facility source areas.

Figure 4.5 shows the spatial distribution of PCBs in small and medium size fish in relation to natural and channelized areas of Dick's Creek. Figure 4.5 indicates that the highest concentrations of PCBs in fish occur in or in close proximity to the natural portions of Dick's Creek. This is important because fish consumption by piscivorous wildlife may be higher in the natural sections of Dick's Creek, leading to higher exposures and risks than were modeled in the BERA. Also, sediment associated PCBs may preferentially deposit in natural sections of Dick's Creek if fewer depositional areas exist in the channelized sections.

Figure 4.6 shows temporal trends in PCB concentrations in longear sunfish and indicates that PCBs in prey fish are not declining in Dick's Creek downstream of apparent facility source areas. Only the longear sunfish data were used in this evaluation of temporal trends in total PCB exposure because it is a consistent and ecologically relevant data set: (1) this species is of a size consumed by wildlife, (2) the use of one species reduces variability due to species-specific differences in PCB exposure, and (3) all fish were collected within a 1.5 mile section of the river that has been contaminated by AK Steel PCB sources.

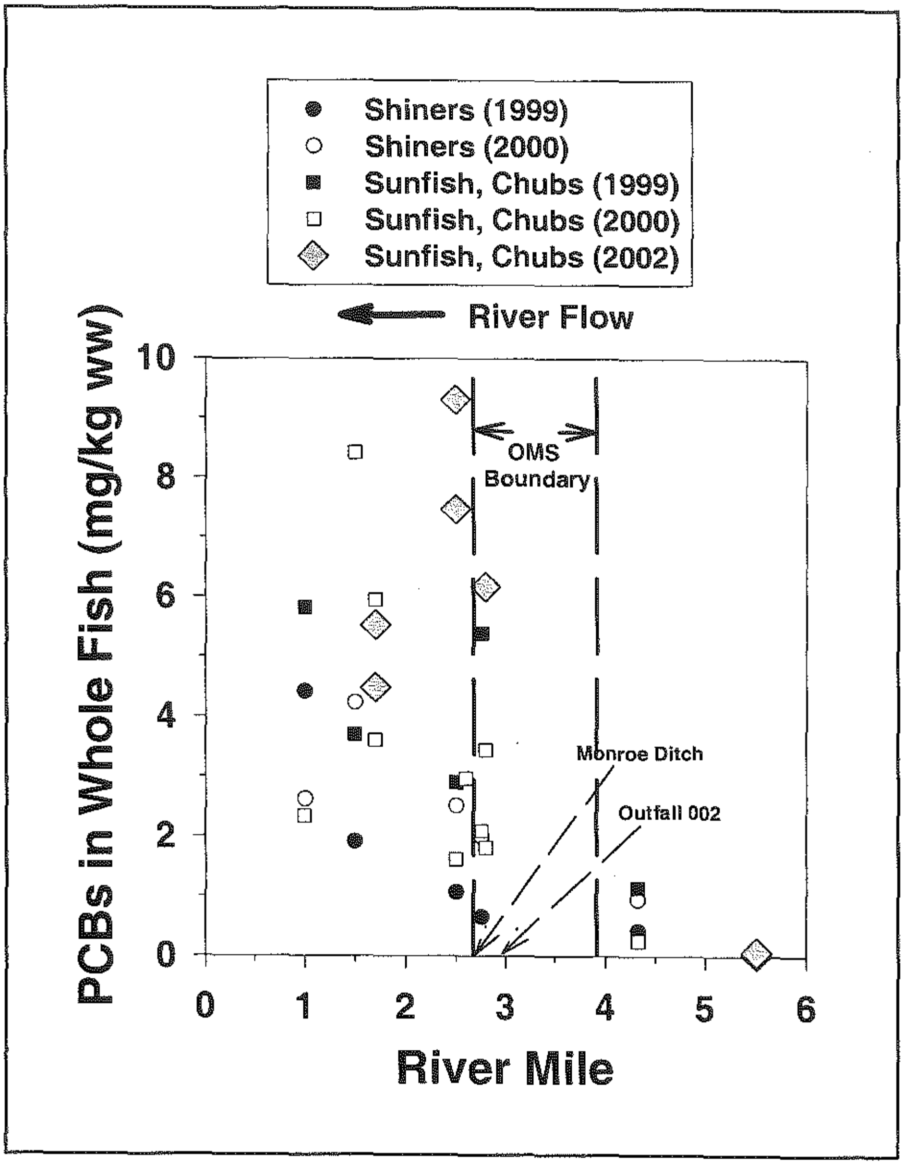

Figure 4.4. Total PCBs in prey fish collected between 1999 and 2002, in relation to the approximate boundary of the AK Steel OMS facility. See Appendix F for data sources and values. Shiners: spotfin shiners; sunfish: longear sunfish and green sunfish; chub: creek chub).

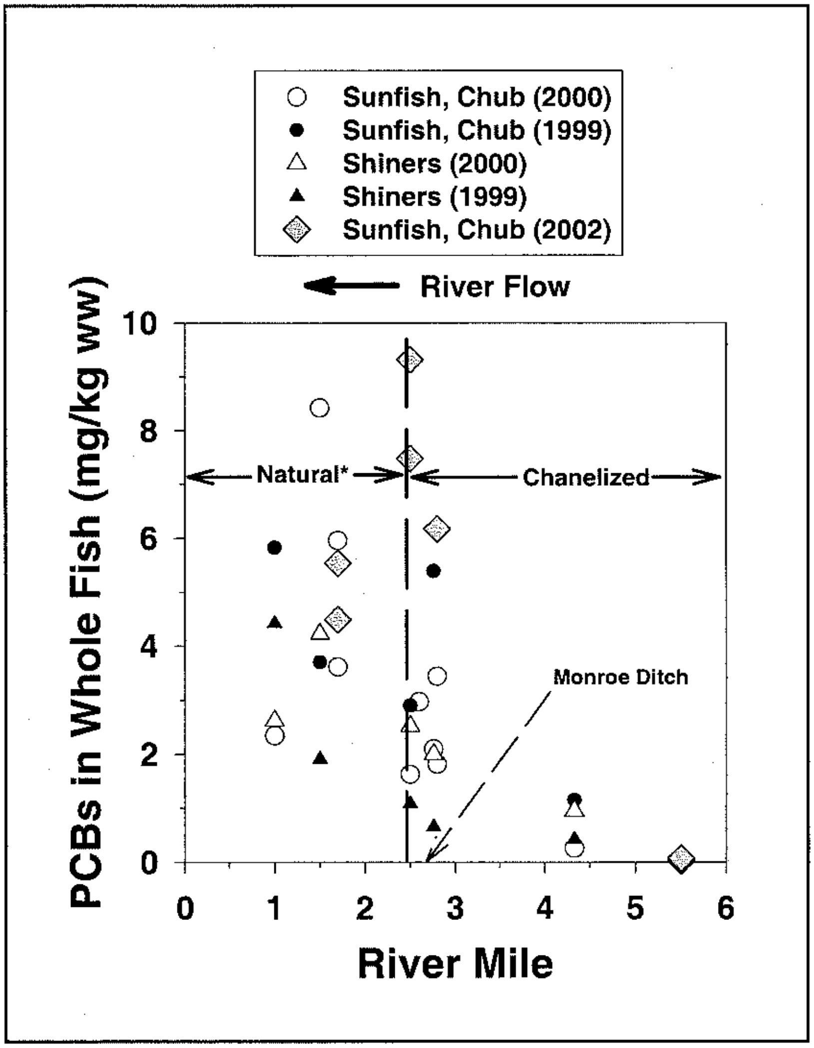

Figure 4.5. Total PCBs in prey fish collected between 1999 and 2002 in natural and channelized sections of Dick's Creek. *Approximately 0.2 miles near river mile 1 is channelized (Arcadis, 2001a).

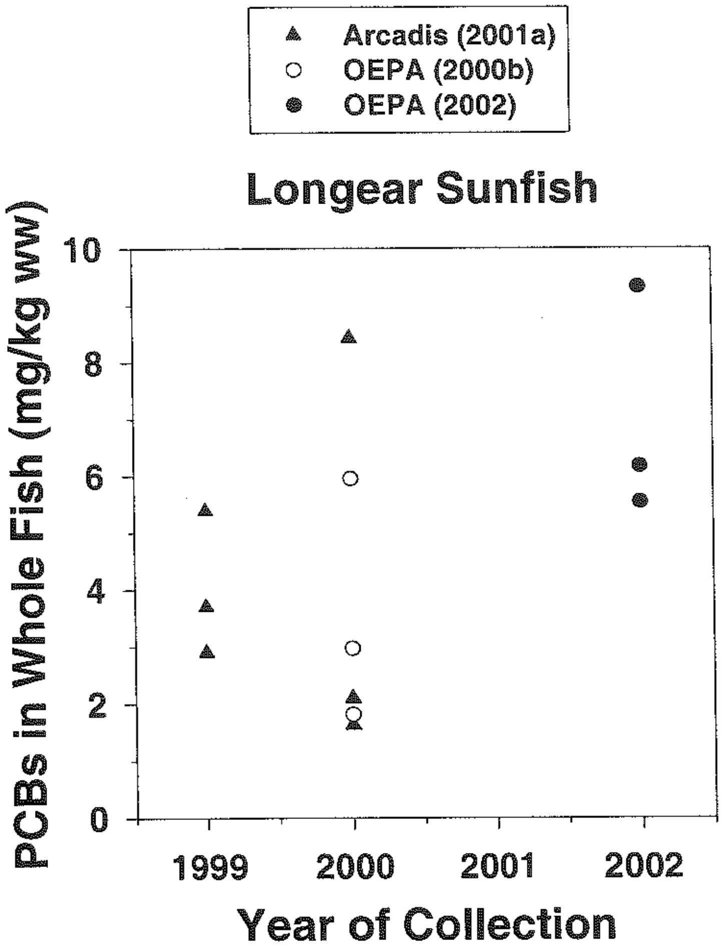

Figure 4.6. Total PCBs in longear sunfish collected between 1999 and 2002 in Dick's Creek showing trends in PCB contamination over time. Fish were collected between approximate river miles 2.8 and 1.5 (see Appendix F).

4.7 Dioxin-like PCB Congeners and Toxicity Equivalence Concentrations

Exposure estimates for dioxin-like PCBs were based on toxicity equivalence concentrations (TECs) and are presented in this section. The data are not used in the primary risk estimation for PCBs (Section 6.2) in the Dick's Creek system because of the degree of extrapolation needed to derive exposure estimates for ecological receptors. However, the exposure concentrations are used as part of the weight-of-evidence assessment (Section 6.3) because (1) dioxin-like PCBs can be considerably more toxic than estimates based on total PCBs (e.g., Barron et al., 1994; USEPA, 2003c), and (2) uncertainties in the extrapolation procedure were incorporated in a probabilistic assessment of exposure and risks.

4.7.1 Dioxin-like PCB Data

The dioxin-like PCB congeners have been identified by the World Health Organization (Van den Berg et al., 1998) and are listed in Appendix G (Table G1-1). The dioxin-like PCB data used in the BERA were from USEPA (2003a), and USEPA (2003b) as follows:

- Surface sediment data (EPA, 2003a). These data indicate that dioxin-like congeners are present in the Dick's Creek system, and that their concentrations increase downstream of apparent facility sources.

- Large fish fillet data (EPA, 2003b). These data were used to estimate egg and whole body fish concentrations of dioxin-like PCBs as described in Section 4.7.3 and Appendix G.

The dioxin-like PCB and TEC data quantitatively used in the BERA are presented in Appendix G.

4.7.2 Calculation of PCB TECs

The cumulative exposure and toxicity of all of the detected dioxin-like PCB congeners are determined by calculating a TEC. The TEC is computed from the concentration of each individual PCB congener multiplied by that congener's potency relative to TCDD. The relative potency of dioxin-like PCB congeners in fish, birds, and mammals has been determined by the World Health Organization (Van den Berg et al., 1998) as toxicity equivalency factors (TEFs). The total TEC is calculated by summing the products of the concentrations of individual congeners [PCB] and their TEFs:

$$TEC = \sum [PCB]*TEF$$

where TEF expresses the potency of the PCB congener relative to TCDD (i.e., TCDD TEF=1). Based on the available data for dioxin-like PCBs (Section 4.7.1), TECs were calculated for large fish fillet data (Table G2-1; Appendix G). Separate TECs were derived using mammalian, avian, and fish TEFs to provide exposure concentrations as TECs for mammals, birds, and fish (see Appendix G).

Note that PCB 156 and PCB 157 could not be separately distinguished in the USEPA (2003a,b) chemistry analyses and the concentration results were presented as a total of PCBs 156 and 157. The total concentrations of PCBs 156 and 157 were used in computing the TEC (the results were not double counted). The TEFs for PCB 156 and PCB 157 are identical, thus this procedure did not increase the uncertainty in the TEC contribution of these congeners.

4.7.3 Estimation of Fish Egg and Whole Body TECs

The only available TEC data in fish were determined in fillets of large fish. These data are not directly applicable to the quantitative assessment of the ecological risks of dioxin-like PCBs, but they provide important direct measures of TEC exposure in fish from Dick's Creek.

The TEC data for large fish fillets were used to estimate exposure concentrations for fish eggs and whole body prey fish concentrations of dioxin-like PCBs. These exposure estimates were derived because TRVs are available for assessing risks to fish based on TEC in eggs (critical body residue approach; Barron et al., 2001) and wildlife from consumption of TEC in prey fish (food chain exposure).

The procedure for estimating fish egg and whole body TECs is described in detail in Appendix G and is briefly summarized below:

1) Fish fillet TEC (ng/kg ww) data were converted to a lipid weight basis (mg/kg lipid) using the reported percentage lipid in each fillet. The lipid conversion was used because PCBs distribute within fish tissues according to their lipid content (i.e., lipid weight concentration should be similar in fillets as in the whole body and in eggs). Lipid normalization is used in extrapolating TEC in congener fillets to TEC in fish eggs and whole body prey fish.

2) TEC in the eggs of large fish (mg/kg lipid) were assumed to equal the fillet TEC (mg/kg lipid). TEC in eggs was then converted to a wet weight exposure basis using literature values for the percentage of lipid in eggs of similar fish species (See Appendix G).

3) TEC in whole body of large fish (mg/kg lipid) were assumed to equal the large fish fillet TEC (mg/kg lipid). Whole body TECs (mg/kg lipid) in prey size fish were then estimated from large fish whole body TECs (mg/kg lipid) by determining a large fish to prey fish PCB ratio. This ratio was determined from site-specific data on total PCBs (mg/kg lipid) in whole body large fish and prey fish collected in the same locations in Dick's Creek. Wet weight TECs in prey fish (mg/kg ww) were then computed from the percentage lipid in the prey fish. See Appendix G for details.

The TEC estimation results are described in detail in Appendix G and included the following:

- TECs in large fish eggs were estimated to range from 0.0013 to 0.017 ng/g ww (Table G2-2).

- TECs in prey fish were estimated to range from 5.4 to 727 ng/kg ww (bird prey) and 26 to 1,600 ng/kg ww (mammal prey) (Table G2-5).

4.8 Wildlife Ingestion Modeling

The quantitative assessment of wildlife risks required the calculation of the exposure concentration as an average daily dose (ADD) of PCBs ingested from the consumption of contaminated prey. An ADD was estimated for each wildlife receptor using a probabilistic assessment; the ranges of ADDs for each wildlife receptor are summarized in Section 6. This section describes the ADD modeling approach.

For each wildlife receptor, an ADD was calculated using a simple dietary exposure model adapted from USEPA (2000) and standard references sources (e.g., Sample et al., 1996):

ADD = ADDd + ADDw + ADDs

Table 4.2 and the following equations define the model parameters and equations:

ADDw = (PCBw x WI)*AUF/BW

ADDs = (PCBs x FS x IRdry)*AUF/BW

ADDd = (PCBvert*PDvert+PCBinvert*PDinvert)*IRwet*AUF/BW.

Appendix B provides the exposure parameters for piscivorous (kingfisher, raccoon, mink) and terrestrial (robin, kestrel) wildlife. Exposure parameters were determined from USEPA (1993) and USEPA (2000) and were considered appropriate for the BERA. For example, the home range of kingfisher used in the BERA was determined by USEPA (2000) to be 0.7 km, which was similar to the 0.39 to 1 km home range determined for kingfishers in a southwestern Ohio stream (Davis, 1982). A uniform distribution of ranges of ecological parameters were used in the risk characterization (Section 6) if multiple values were reported (e.g., range of body weights for female and male animals).

An area use factor (AUF) is a parameter used to lower wildlife exposure by the fraction the receptor may feed outside of the affected site habitat (AH). For example, an AUF of 0.7 indicates the receptor would only be exposed throughout 70% of its home range (HR). An AUF was estimated for each receptor from the spatial extent of the AH and the HR for each wildlife receptor: AUF = AH/HR. Home ranges were determined from species-specific information (Appendix B), and the size of the affected habitat was determined as described below.

Table 4.2. Wildlife Exposure Model Parameter Definitions[1]			
Parameter	**Units**	**Definition**	**Source**
ADD	mg/kg*d	average total daily ingested dose of PCBs	calculated
ADDd	mg/kg*d	average daily ingested dose of PCBs in diet	calculated
ADDw	mg/kg*d	average daily ingested dose of PCBs in drinking water	calculated
ADDs	mg/kg*d	average daily ingested dose of PCBs from incidental sediment or soil ingestion	calculated
PCBw	mg/L	PCBs in surface water	----[2]
WI	L/d	water ingestion rate	Appendix B
AUF	unitless	area use factor	Appendix B
BW	kg (ww)	body weight	Appendix B
PCBs	mg/kg (dw)	PCBs in sediment or soil	Appendix F
FS	unitless	incidental sediment or soil ingestion (fraction of diet)	Appendix B
IRdry	kg/d (dw)	total food ingestion rate	Appendix B
PCBvert	mg/kg (ww)	PCBs in vertebrate prey	Appendix F
PDvert	unitless	proportion of diet as vertebrate prey	Appendix B
PCBinvert	mg/kg (ww)	PCBs in invertebrate prey	Appendix F
PDinvert	unitless	proportion of diet as invertebrate prey	Appendix B

1. Exposure units for TECs are in units of ng/kg ww and ng/kg*d ww (Appendix G).
2. A value of 0 mg/L PCBs was used as the surface water concentrations for assessing wildlife risks.

A kingfisher and mink AH of 6.44 km for Dick's Creek was computed from an estimated four river miles of affected habitat, which resulted in an area use factor of 1 (Appendix B). For raccoon, a mean AH of 38.3 hectares was calculated from an estimated four river miles of affected habitat with an average width of 0.037 miles that included floodplain and riparian areas. This may be an underestimate of the affected raccoon habitat because it does not consider the habitat area of Monroe Ditch. A raccoon AUF range of 0.6 to 1 was used in the probabilistic assessment. In comparison, AquaQual (2001) noted that channelized sections of Dick's Creek had established riparian areas in proximity to AK Steel (e.g., 20 to 40 meters beyond the controlled grassy areas). Natural sections of Dick's Creek had riparian zones up to 100 meters on both banks of the creek. Photographs taken during the June 2000 site visit also show riparian areas in the channelized section of Dick's Creek in proximity to AK Steel (Appendix D).

Exposure duration (ED; Appendix B) is a factor that accounts for any migration or hibernation/estivation that would reduce exposure below that needed to cause adverse effects. The ED was defined as one for all species in the BERA because they are anticipated to be exposed for a duration that is applicable to the TRVs used to characterize risks (i.e., there is no reduction in the ADD because residency of wildlife receptors is of sufficient duration each year to be exposed to the ADD). Because ED was set with a value of one, it does not appear in the above equations.

Floodplain exposures to terrestrial wildlife were assessed by modeling ingestion of soil invertebrate prey by robins and small mammal ingestion by kestrels (Appendix B). Ingestion of PCB-contaminated soil invertebrates and small mammals was also assessed in additional modeling scenarios for raccoons (Table B2) and mink (Table B3) because wildlife receptors may feed on terrestrial organisms in addition to aquatic prey (see Appendix B).

4.9 Background Levels of PCBs

For the purposes of the BERA, background concentrations of PCBs were defined as PCBs in surface sediment, surface water, and biota present in Dick's Creek and Monroe Ditch upstream of apparent facility source areas. Specifically for the BERA, background data were defined as (1) samples collected in Monroe Ditch near Todd Hunter Road, and (2) samples collected in Dick's Creek between river mile 4 and the confluence with the North Branch of Dick's Creek (approximately river mile 5.5). River mile 4 is upstream of all apparent facility PCB sources and provides a sufficient number of samples to characterize PCB background levels. As discussed in this BERA, facility-related PCB contamination is evident beginning at approximately river mile 3 and Outfall 002. Background areas in Dick's Creek were considered to occur at river mile 4 in the BERA because wildlife may be exposed to facility-related PCB contamination upstream of Outfall 002 if mobile prey species (i.e., fish) that bioaccumulate PCBs downstream of facility source areas are caught in upstream areas. Also, the approximate upstream boundary of the AK Steel OMS facility occurs near river mile 4.

Total PCB background concentrations are listed in Appendix F and are defined as follows:

- Sediment: PCB concentrations in surface sediment sampled from background areas were either not detected or had a maximum concentration of 0.01 mg/kg dw.

- Aquatic plants: PCBs were not detected in aquatic plants from background areas at a maximum detection limit of 0.033 mg/kg ww.

- Benthic invertebrates: PCBs were not detected in benthic invertebrates from background areas at a maximum detection limit of 0.04 mg/kg ww.

- Fish: PCBs in fish collected from background areas ranged from 0.0321 to 1.15 mg/kg ww. Fish may be mobile in Dick's Creek, and some background PCBs may be derived from exposure to downstream PCB-contaminated areas.

4.10 Trends in PCB Exposure

Multiple AK Steel sources of PCBs exist along the site boundary, including contaminated groundwater, Outfall 002 sediment, and Monroe Ditch. Additionally, PCBs are present in surface and subsurface sediment and floodplain soil in proximity to and downstream of facility source areas. The available data show that PCBs substantially increase in sediment, aquatic plants, benthic invertebrates, and fish downstream of these source areas (e.g., Figures 4.3 and 4.4). PCB contamination has been detected for over three miles of Dick's Creek, nearly to its confluence with the Great Miami River, and the available recent data (1999 to 2003) do not show any apparent declines in PCB concentrations (e.g., Figure 4.6). Background levels of PCBs in the Dick's Creek system are either low or not detectable.

4.11 PCB Fingerprinting

DeGrandchamp (2003) performed a statistical fingerprint analysis to identify and compare PCB congeners detected in sediment and floodplain soil in proximity and downstream of the AK Steel site to PCBs in upstream background areas. The results of this analysis indicated that:

- PCBs detected in 2003 sediments and floodplain soils of Dick's Creek downstream of Outfall 002 had only one unique fingerprint; the only exception was a single low concentration sample that was several miles downstream of the facility.

- The PCB fingerprint of 2003 samples collected in upstream background areas differ significantly from downstream areas affected by apparent PCB releases at Outfall 002 and Monroe Ditch.

- PCBs detected in 2003 sediment and floodplain samples in Dick's Creek downstream of Outfall 002 were attributed to the AK Steel site.

- There was no evidence to support significant additional sources of PCBs to Dick's Creek other than AK Steel.

5. Effects Analysis

5.1 Overview

This section summarizes the adverse effects information for PCBs in Dick's Creek, including TRVs (Section 5.2), site-specific toxicity testing (Section 5.3), ecological survey results (Section 5.4), dioxin-like PCB toxicity (Section 5.5). As discussed below, TRVs were obtained primarily from the ERA for the Hudson River where Aroclor 1242 was primarily released (USEPA, 2000). Other sources of TRVs are from peer-reviewed scientific literature (MacDonald et al., 2000b; Elonen et al., 1998). The selected TRVs have been previously rigorously evaluated and peer reviewed and are considered to be applicable to assessing risks in Dick's Creek as discussed below. Table 5.1 lists the TRVs used in the BERA. NOAEL and LOAEL TRVs were used in assessing risks, which USEPA (1997; p. 7-4, 7.3.1 1st para) and ORNL (1998) considered to be the lower and upper threshold for ecological effects. Exceedences of TRV values were interpreted to be indicative of ecological effects, with the exceedence of a LOAEL TRV having the greatest certainty that risks were present.

5.2 Toxicity Reference Values: Total PCBs

5.2.1 Media TRVs

The sediment TRVs were the threshold effect concentration (0.035 mg/kg dw; NOAEL) and medium effect concentration (0.34 mg/kg dw; LOAEL). Additionally, a severe effects TRV of 1.6 mg/kg dw from MacDonald et al. (2000b) was also used to assess the probability of severe impacts on the benthic community of Dick's Creek. These values are consensus effect levels for PCBs in freshwater sediment from MacDonald et al. (2000b). These freshwater sediment values differ slightly from the USEPA (2000) TRVs used in the Hudson River ERA, which were applicable to both freshwater and estuarine sediments.

The applicable surface water TRV was the chronic AWQC value of 0.014 μg/L. State of Ohio water quality criteria for PCBs were not available for the Ohio River Basin.

5.2.2 Fish Critical Body Residue TRVs

Because of the limited surface water data, PCB effects on fish were determined using a critical body residue (CBR) approach. CBRs are known to be highly variable (Barron et al., 2001), and USEPA (2000) determined a range of PCB tissue residues of 1.9 to 9.3 mg/kg to be appropriate TRVs for evaluating the adverse effects of PCBs on a variety of fish species. This range of TRVs was used in assessing risks to fish in Dick's Creek.

Table 5.1. Toxicity Reference Values (TRVs) for Total PCBs and Dioxin-like PCB Congener Toxicity Equivalence Concentrations (TECs)						
Receptor	**Pathway**	**PCB-Type**	**Units**	**NOEC TRV**	**LOEC TRV**	**Source**
Benthic invertebrates	Sediment	total PCBs	mg/kg dw 1% OC	0.035	0.34	MacDonald et al. (2000b)
Fish	Whole body residue	total PCBs	mg/kg ww	1.9	9.3	Tables 4-25a (USEPA, 2000)[1]
	Egg residue	TEC	ng/g lipid	8	18	
			ng/g ww	0.235	0.435	Elonen et al. (1998)[2]
	Surface water	total PCBs	µg/L	0.014[4]	0.014[4]	USEPA (2002)
Birds[3]	Ingestion	total PCBs	mg/kg*d	1.8	7.1	Table 4-26a (USEPA, 2000)[1]
		TEC	ng/kg*d	1.4	14	
Raccoon	Ingestion	total PCBs	mg/kg*d	0.32	1.5	Table 4-27a,b (USEPA, 2000)[1]
		TEC	ng/kg*d	1	10	
Mink	Ingestion	total PCBs	mg/kg*d	0.004	0.04	Table 4-27a (USEPA, 2000)[1]
		TEC	ng/kg*d	0.08	2.24	

1. TRVs were the preferred values selected by EPA (2000) for the Hudson River ERA.
2. Lowest values for cyprinids (minnow family) and ictalurids (catfish family).
3. Birds: kingfisher, robin, kestrel. TEC benchmark only applied to kingfisher (no terrestrial TEC data in wildlife prey).
4. Chronic ambient water quality criteria (AWQC) value based on bioaccumulation in fish.

5.2.3 Wildlife TRVs

Wildlife TRVs were determined from the species-specific NOAELs and LOAELs presented in USEPA (2000). Bird TRVs of 1.8 mg/kg*d (NOAEL) and 7.1 mg/kg*d (LOAEL) were used for both terrestrial wildlife (robin, kestrel) and piscivorous birds (kingfisher). Mammal TRVs were determined for both mink and raccoon. Mink are recognized as one of the mammalian species most sensitive to PCBs (e.g., Brunstrom et al., 2001) and had ingestion TRVs of 0.004 mg/kg*d (NOAEL) and 0.04 mg/kg*d (LOAEL) that were 8 to over 100 times lower (more sensitive) than TRVs for the raccoon (NOAEL: 0.32 mg/kg*d; LOAEL: 1.5 mg/kg*d) and birds.

5.3 Site-Specific Toxicity Testing

AquaQual (2001) performed both laboratory and in-situ (in-stream) toxicity testing in Dick's Creek and considered the in-situ data to be more sensitive and apparently more representative of PCB toxicity in Dick's Creek. The results of in-situ toxicity tests conducted in 1999 and 2000 that were summarized by AquaQual (2001) included:

- High mortality in sediment and pore water exposures of aquatic invertebrates at locations downstream of the site
- Significant correlations between survival and PCB concentrations in surficial sediments
- Highest mortality in-situ bioassay chambers occurred at the highest pore water concentrations of PCBs.

These results are discussed in the weight-of-evidence and uncertainty analysis (Section 6) but are not used to quantify risks to benthic invertebrates.

5.4 Ecological Surveys

The most recent reported ecological surveys of Dick's Creek have been performed by Arcadis (2001a) and AquaQual (2001) in 2000. AquaQual (2001) evaluated macrohabitat quality using a Qualitative Habitat Evaluations Index (QHEI), and conducted a qualitative survey of benthic macroinvertebrates in sediment samples. Arcadis (2001a) evaluated habitat quality using QHEI scores, and also evaluated the Index of Biotic Integrity and Index of Well-Being for fish, and Invertebrate Community Index. The results of these surveys are discussed below and in Section 6, but are not used to quantify risks to ecological receptors. Historical ecological surveys in Dick's Creek are documented in OEPA (2000d).

AquaQual (2001) considered the Dick's Creek stream habitat to be of adequate quality, but survey results indicated poor quality benthic and fish communities. For example, few species of macroinvertebrates were present, pollution tolerant species dominated, and there was evidence of high bivalve mortality (AquaQual, 2000).

The most recent quantitative 2000 ecological survey reported by Arcadis was reported in

Attachment A of Arcadis (2001a) and is summarized in Table 5.2 below. The results of this survey indicated that (1) Dick's Creek had very poor to good habitat in proximity to and downstream of AK Steel, (2) two of the sample locations did not meet biological criteria scores for macroinvertebrates, and (3) all locations met fish criteria.

Table 5.2. Summary of Dick's Creek Ecological Survey Results for 2000 (Arcadis, 2001a)[1, 2]

Station Number	River Mile[3]	Habitat Quality (QHEI)	Benthic Invertebrate Community	Fish Community
6	6.3	poor	non-attainment	non-attainment
2	5	fair	met criteria	met criteria
3	4.4	fair	met criteria	met criteria
4	3	very poor	non-attainment	met criteria
5	2.4 - 2.6	fair	non-attainment	met criteria
10	0.2 - 0.6	good	met criteria	met criteria

1. Source: Attachment A, Arcadis (2001a): Biological Survey of Dick's Creek and its Tributaries, 2000. Habitat quality and community condition results were determined by Arcadis (2001a) from a comparison to Ohio water quality standards and the QHEI.
2. Shaded cells are background areas upstream of apparent facility PCB sources at Outfall 002 and Monroe Ditch.
3. Approximate river mile determined from Arcadis (2001a). Station 6 is upstream of the AK Steel site.

5.5 Dioxin-like PCB Toxicity

The toxicity of dioxin-like PCB congeners was quantitatively assessed as part of the weight-of-evidence evaluation using TEC-based TRVs, consistent with USEPA (2003a). Receptor-specific TECs were developed as follows:

- Fish eggs. The developmental toxicity of dioxin-like PCBs bioaccumulated in fish was determined from critical body residue-based TRVs for fish eggs. TEC-based TRVs were determined from the lowest no effect and low effect concentrations of TCDD exposure to fish eggs of the same species (channel catfish) or family (fathead minnow, white sucker) reported by Elonen et al. (1998). The TEC-TRVs were 0.235 ng/g ww (NOAEL) and 0.435 ng/g ww (LOAEL).

- Birds. The reproductive and developmental toxicity of dioxin-like PCBs in the prey of kingfishers was determined from NOAEL (1.4 ng/kg*d) and LOAEL (14 ng/kg*d) reported by USEPA (2000).

- Mammals. The reproductive and developmental toxicity of dioxin-like PCBs in the prey of raccoons was determined from NOAEL (1 ng/kg*d) and LOAEL (10 ng/kg*d) reported by USEPA (2000). The reproductive and developmental toxicity of dioxin-like PCBs in the prey of mink was determined from NOAEL (0.08 ng/kg*d) and LOAEL (2.24 ng/kg*d) reported by USEPA (2000).

Invertebrates appear to be relatively insensitive to the dioxin-like toxicity of PCBs (USEPA, 2003c) and TEC risks were not assessed for these receptors; total PCB risks to benthic invertebrates were assessed as described in Section 6. TEC risks to terrestrial wildlife was not assessed because of an absence of data for dioxin-like PCBs in terrestrial prey organisms. This is discussed as an uncertainty in Section 6.

6. Risk Characterization

6.1 Overview

PCB risks to benthic invertebrates, fish, and piscivorous and terrestrial wildlife were identified in the risk screening of the problem formulation (Section 2). Section 6.2 below provides quantitative risk estimates for these receptors. A probabilistic assessment of PCB risks was used because it incorporates the variability and uncertainty in exposure and toxicity and provides directly interpretable risk descriptions for risk managers (USEPA, 1999a). Point estimate approaches were used in both the two previous risk assessments for Dick's Creek (Arcadis, 2001a; AquaQual, 2001) but differed in both the characterization and conclusions regarding PCB risks to aquatic life and wildlife because of the assumptions and interpretations applied in the risk assessments.

PCB risks to aquatic plants, soil invertebrates and plants, and herbivorous wildlife were determined to be minimal in the risk screening of the problem formulation (Section 2). The risks to these receptors are discussed in the risk description and weight-of-evidence evaluation in Section 6.3 below. Section 6.3 also considers additional information in the weight-of-evidence for benthic invertebrates, fish, and piscivorous and terrestrial wildlife (e.g., ecological surveys, bioassays, dioxin-like PCB toxicity).

Section 6.4 presents the uncertainty analysis, including consideration of the uncertainties in the exposure, toxicity, and risks to ecological receptors, COPCs and non-detected chemicals, and background risks.

6.2 Probabilistic Risk Estimation for Total PCBs

Risks were estimated as a probability distribution of HQs (HQ = [PCBs]/TRV) in probabilistic simulations (Latin Hypercube sampling; 10,000 iterations) using @Risk software (Palasade Corporation). Total PCB exposures [PCBs] were determined from the probability distribution function (e.g., mean, standard deviation; log normal distribution) listed in Table 4.1 (see Section 4 for details). TRVs were defined as the point value or uniform distribution of ranges listed in Table 5.1 (see Section 5 for details). The quantitative assessment of risks to the four categories of receptors (benthic invertebrates, fish, piscivorous and terrestrial wildlife) that were determined to be at risk in the problem formulation are presented below. Tables 6.1 to 6.7 list the results of the risk estimation, including the ranges of PCB exposures, HQs, and percentages of risk exceedences that were determined in risk simulations.

6.2.1 Benthic Invertebrates

Benthic invertebrates were at high risk from total PCBs in sediments, with LOAEL HQs ranging from 0.006 to 97.3, and a probability of exceeding medium effect concentrations of 79.4% (Table 6.1). The medium effects LOAEL is the sediment concentration of PCBs at which adverse effects frequently occur (MacDonald et al., 2000b). There was a 37.9% probability of exceeding severe effects levels in the Dick's Creek system (Table 6.1), which is the concentration of PCBs above which adverse effects usually or always occur (MacDonald et al., 2000b).

Table 6.1. Ranges of Exposure and Risks of Total PCBs to Benthic Invertebrates Exposed to Sediment[1]

Total PCB Exposure[2]	TRV	Hazard Quotient	% Exceedences[3]
0.005 - 33.0 (mg/kg dw 1% OC)	NOAEL - LOAEL	0.017 - 519	89.6%
	LOAEL	0.006 - 97.3	79.4%
	Severe Effect	0.0037 - 20.7	37.9%

1. HQs are estimated for each category of TRV. The range of HQs is determined from probabilistic calculations of the ratio of (1) the probability distribution of PCB exposure (see Table 4.1) and (2) the probability distribution of the NOAEL and the LOAEL, or the severe effect level. See Table 5.1 for TRVs.
2. Sediment concentrations of PCBs are normalized to 1% OC. See Section 4.
3. The percentage of HQs that exceed a value of 1.

6.2.2 Fish

Fish in the Dick's Creek system may be at risk from total PCBs bioaccumulated in their tissues. LOAEL HQs ranged from 0.026 to 1.84, with a probability of exceeding CBR toxicity levels of 6.13% (Table 6.2). HQs based on the range of NOAEL and LOAEL TRVs ranged from 0.04 to 8.2 with a 30.4% probability of exceeding toxicity thresholds (Table 6.2).

6.2.3 Piscivorous Wildlife

Risks to piscivorous wildlife from total PCBs in the Dick's Creek system were species-dependent:

- Kingfishers did not appear to be at risk from ingestion of total PCBs. There was a less than 1% probability of risk exceedences (Table 6.3).
- Raccoons did not appear to be at risk from ingestion of total PCBs. There was maximum of a 1% probability of risk exceedences (Table 6.4).
- Mink were at high risk from ingestion of total PCBs. LOAEL HQs ranged from 0.8 to 112, with a greater than 99% probability of exceeding LOAEL TRVs (Table 6.5). Mink and other mustelids are known to be extremely sensitive to the reproductive and developmental effects of PCBs.

Piscivorous wildlife that feed in the Dick's Creek floodplain in addition to preying on aquatic organisms, are at increased risks from total PCB exposures. However, even with consumption of PCB-contaminated terrestrial prey, risks to raccoon were still low (Table 6.4). For mink there was a greater than 99% probability of mink risks even in the absence of floodplain contributions.

Table 6.2. Ranges of Exposure and Risks of Total PCBs to Fish from Critical Body Residues[1]

Total PCB Exposure[2]	TRV	Hazard Quotient	% Exceedences[3]
0.255 - 17.1 (mg/kg ww)	NOAEL - LOAEL	0.040 - 8.22	30.4%
	LOAEL	0.026 - 1.84	6.13%

1. HQs are estimated for each category of TRV. The range of HQs is determined from probabilistic calculations of the ratio of (1) the probability distribution of PCB exposure (see Table 4.1) and (2) the probability distribution of the NOAEL and the LOAEL. See Table 5.1 for TRVs.
2. Whole body concentrations of PCBs in small, medium, and large fish. See Section 4.
3. The percentage of HQs that exceed a value of 1.

Table 6.3. Ranges of Exposure and Risks of Total PCBs to Kingfishers[1]

Total PCB Exposure[2]	TRV	Hazard Quotient	% Exceedences[3]
0.122 - 2.97 (mg/kg*d)	NOAEL - LOAEL	0.029 - 1.51	<1%
	LOAEL	0.017 - 0.419	<1%

1. HQs are estimated for each category of TRV. The range of HQs is determined from probabilistic calculations of the ratio of (1) the probability distribution of PCB exposure (see Table 4.1) and (2) the probability distribution of the NOAEL and the LOAEL. See Table 5.1 for TRVs.
2. Dietary intake of PCBs; includes ingestion of fish, benthic invertebrates, and incidental ingestion of sediment; see Appendix B.
3. The percentage of HQs that exceed a value of 1.

Table 6.4. Ranges of Exposure and Risks of Total PCBs to Raccoons[1]				
Scenario	**Total PCB Exposure**	**TRV**	**Hazard Quotient**	**% Exceedences[4]**
Only aquatic organisms as prey	0.001 - 0.199[2] (mg/kg*d)	NOAEL - LOAEL	0.010 - 0.472	<1%
		LOAEL	0.009 - 0.132	<1%
Both aquatic and floodplain organisms as prey	0.018 - 1.30[3] (mg/kg*d)	NOAEL - LOAEL	0.009 - 3.19	1.23%
		LOAEL	0.012 - 0.865	<1%

1. HQs are estimated for each category of TRV. The range of HQs is determined from probabilistic calculations of the ratio of (1) the probability distribution of PCB exposure (see Table 4.1) and (2) the probability distribution of the NOAEL and the LOAEL. See Table 5.1 for TRVs.
2. Scenario 1: Dietary intake of PCBs; includes ingestion of fish, benthic invertebrates, and incidental ingestion of sediment; see Appendix B.
3. Scenario 2: Dietary intake also includes ingestion of floodplain organisms; see Appendix B.
4. The percentage of HQs that exceed a value of 1.

6.2.4 Terrestrial Wildlife

Risks to terrestrial wildlife from total PCBs in the Dick's Creek floodplain were species-dependent:

- Robins were at risk from ingestion of total PCBs with a 10.8% probability of exceeding LOAEL HQs (Table 6.6). HQs based on the range of NOAEL and LOAEL TRVs ranged from 0.002 to 20 with a 20.8% probability of exceedences (Table 6.6).
- Kestrels did not appear to be at risk from ingestion of total PCBs. There was a less than 1% probability of risk exceedences (Table 6.7).

Table 6.5. Ranges of Exposure and Risks of Total PCBs to Mink[1]				
Scenario	**Total PCB Exposure**	**TRV**	**Hazard Quotient**	**% Exceedences[4]**
Only aquatic organisms as prey	0.019 - 0.527[2] (mg/kg*d)	NOAEL - LOAEL	0.543 - 109	100%
		LOAEL	0.565 - 13.2	99.9%
Both aquatic and floodplain organisms as prey	0.024 - 0.520[3] (mg/kg*d)	NOAEL - LOAEL	0.812 - 112	100%
		LOAEL	0.610 - 13.0	99.8%

1. HQs are estimated for each category of TRV. The range of HQs is determined from probabilistic calculations of the ratio of (1) the probability distribution of PCB exposure (see Table 4.1) and (2) the probability distribution of the NOAEL and the LOAEL. See Table 5.1 for TRVs.
2. Scenario 1: Dietary intake of PCBs; includes ingestion of fish, benthic invertebrates, and incidental ingestion of sediment; see Appendix B.
3. Scenario 2: Dietary intake also includes ingestion of floodplain organisms; see Appendix B.
4. The percentage of HQs that exceed a value of 1.

Table 6.6. Ranges of Exposure and Risks of Total PCBs to Robins[1]			
Total PCB Exposure[2]	**TRV**	**Hazard Quotient**	**% Exceedences[3]**
0.004 - 44.7 (mg/kg*d)	NOAEL - LOAEL	0.002 - 20.1	20.81%
	LOAEL	0.0004 - 7.38	10.8%

1. HQs are estimated for each category of TRV. The range of HQs is determined from probabilistic calculations of the ratio of (1) the probability distribution of PCB exposure (see Table 4.1) and (2) the probability distribution of the NOAEL and the LOAEL. See Table 5.1 for TRVs.
2. Dietary intake of PCBs; includes ingestion of soil invertebrates, and incidental ingestion of soil; see Appendix B.
3. The percentage of HQs that exceed a value of 1.

Table 6.7. Ranges of Exposure and Risks of Total PCBs to Kestrels[1]			
Total PCB Exposure[2]	**TRV**	**Hazard Quotient**	**% Exceedences[3]**
0.0002 - 3.61 (mg/kg*d)	NOAEL - LOAEL	0.0001 - 1.36	<1%
	LOAEL	0.00002 - 0.51	<1%

1. HQs are estimated for each category of TRV. The range of HQs is determined from probabilistic calculations of the ratio of (1) the probability distribution of PCB exposure (see Table 4.1) and (2) the probability distribution of the NOAEL and the LOAEL. See Table 5.1 for TRVs.
2. Dietary intake of PCBs; includes ingestion of small mammals; see Appendix B.
3. The percentage of HQs that exceed a value of 1.

6.3 Risk Description and Weight-of-Evidence Evaluation

This section describes risks to ecological receptors inhabiting and using the Dick's Creek system, based on the quantitative risk estimation in Section 6.2 and the risk screening in Section 2. The weight-of-evidence evaluation considers risks of dioxin-like PCB congeners in addition to total PCBs and considers additional information such as the results of ecological surveys and toxicity tests. Exceedences of LOAEL TRVs for an ecological receptor are interpreted as sufficient evidence that risks are present in the Dick's Creek system. HQs that exceed a value of one using the range of NOAEL and LOAEL TRVs indicate that risks are likely present, but additional lines of evidence are needed to make a definitive determination of risk. Uncertainties in the risk characterization are discussed in Section 6.4.

6.3.1 Aquatic Plants

Aquatic plants sampled downstream of the AK Steel site had a maximum tissue concentration of total PCB of 0.284 mg/kg ww (Table A1; Appendix A). Risks of PCBs to aquatic plants were not quantitatively assessed because of limited toxicity data and apparent low sensitivity, as evidenced by high PCB bioaccumulation without apparent adverse effects (Stange and Swackhamer, 1994). Aquatic plants were considered a pathway to herbivorous wildlife (Section 6.3.6).

6.3.2 Benthic Invertebrates

Probabilistic risk estimates indicated that benthic invertebrates are at risk from contact with PCB-contaminated sediment in Dick's Creek (Section 6.2). Figure 6.1 compares the spatial distribution of PCBs in sediment (mg/kg 1% OC) to medium and severe effects levels for benthic invertebrates. Figure 6.1 shows that toxic levels of total PCBs exist adjacent to and downstream of the AK Steel site, but PCB concentrations in Dick's Creek are below toxicity levels at locations upstream of approximate river mile 3. This figure also shows that sediment PCBs in the Outfall 002 ditch and Monroe Ditch are also present at toxic levels. Total PCBs in sediments downstream of the site also exceeded the sediment quality threshold derived for the Green Bay BERA of 0.032 mg/kg (RETEC, 2002). The Green Bay BERA was a large scale assessment of PCB contamination and risks in the Lower Fox River and Green Bay, Lake Michigan performed for the Wisconsin Department of Natural Resources by RETEC (2002). RETEC (2002) considered the sediment quality thresholds for PCBs to be protective sediment values for ecological receptors and "working values" from which to select a remedial action level.

The presence of toxic levels of PCBs in the Dick's Creek system downstream of apparent facility source areas is also consistent with site-specific toxicity test results (AquaQual, 2001) and ecological surveys (AquaQual, 2001; Arcadis, 2001a). For example, AquaQual (2001) reported mortality in sediment, pore water, and water column exposures of aquatic invertebrates at locations downstream of the facility, and there were significant correlations between survival and PCB concentrations in surficial sediments. Both AquaQual (2001) and Arcadis (2001a) reported an impaired benthic community at locations downstream of the AK Steel site. In the Arcadis (2001a) survey performed in 2000, the only location with fair to good habitat quality that did not meet ecological criteria for benthic invertebrate communities was approximately at river mile 2.45, which is downstream of Monroe Ditch.

The available lines of evidence show that benthic invertebrates are at substantial risk from PCBs in sediments from the AK Steel site. This conclusion is considered to be of high confidence because the spatial extent of PCBs has been well characterized, and risks were determined using TRVs indicative of potential population-level effects. Impacts to the benthic invertebrate community may also result in indirect impacts to other ecological receptors in the Dick's Creek system because of a contaminated and impaired prey base.

6.3.3 Fish

Probabilistic risk estimates indicate that fish may be at risk from bioaccumulation of total PCBs in Dick's Creek. Figure 6.2 compares the spatial distribution of PCBs in fish to NOAEL and LOAEL critical body residue values for PCBs. This figure shows that potentially toxic levels of PCBs exist near Monroe Ditch and locations downstream of the AK Steel site. This figure also demonstrates that fish tissue concentrations of PCBs are below no effect levels upstream of Outfall 002. Exceedences of the AWQC for PCBs in surface water could not be determined from the chemistry data sources used in the BERA because of elevated detection limits. Total PCB concentrations in sediments within and downstream of the facility also exceeded the LOAEL sediment quality threshold derived for the Green Bay ERA of 1.8 to 3.6 mg/kg for the protection of fish (RETEC, 2002). Assessment of the embryonic toxicity of dioxin-like PCBs from PCBs bioaccumulated in the parent fish indicated a low potential for toxicity of PCBs as TECs (Appendix G). Maximum TEC concentrations (0.017 ng/g ww; 0.354 ng/g lipid; Appendix G Table G2-2) were below TEC-based TRVs for fish eggs (Table 5.1).

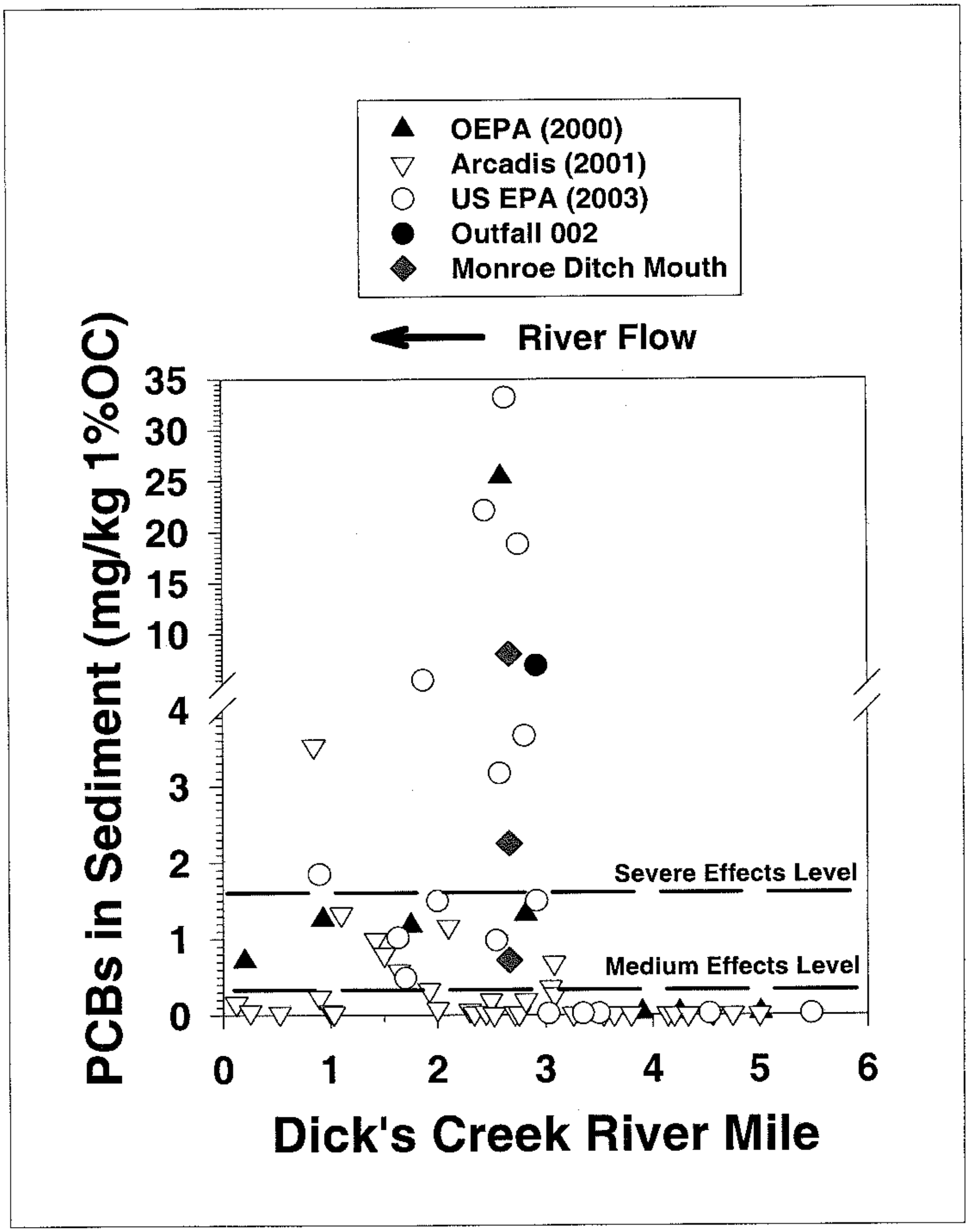

Figure 6.1. Comparison of total PCBs in surface sediment normalized to 1% OC to medium and severe freshwater sediment effect levels (MacDonald et al., 2000b).

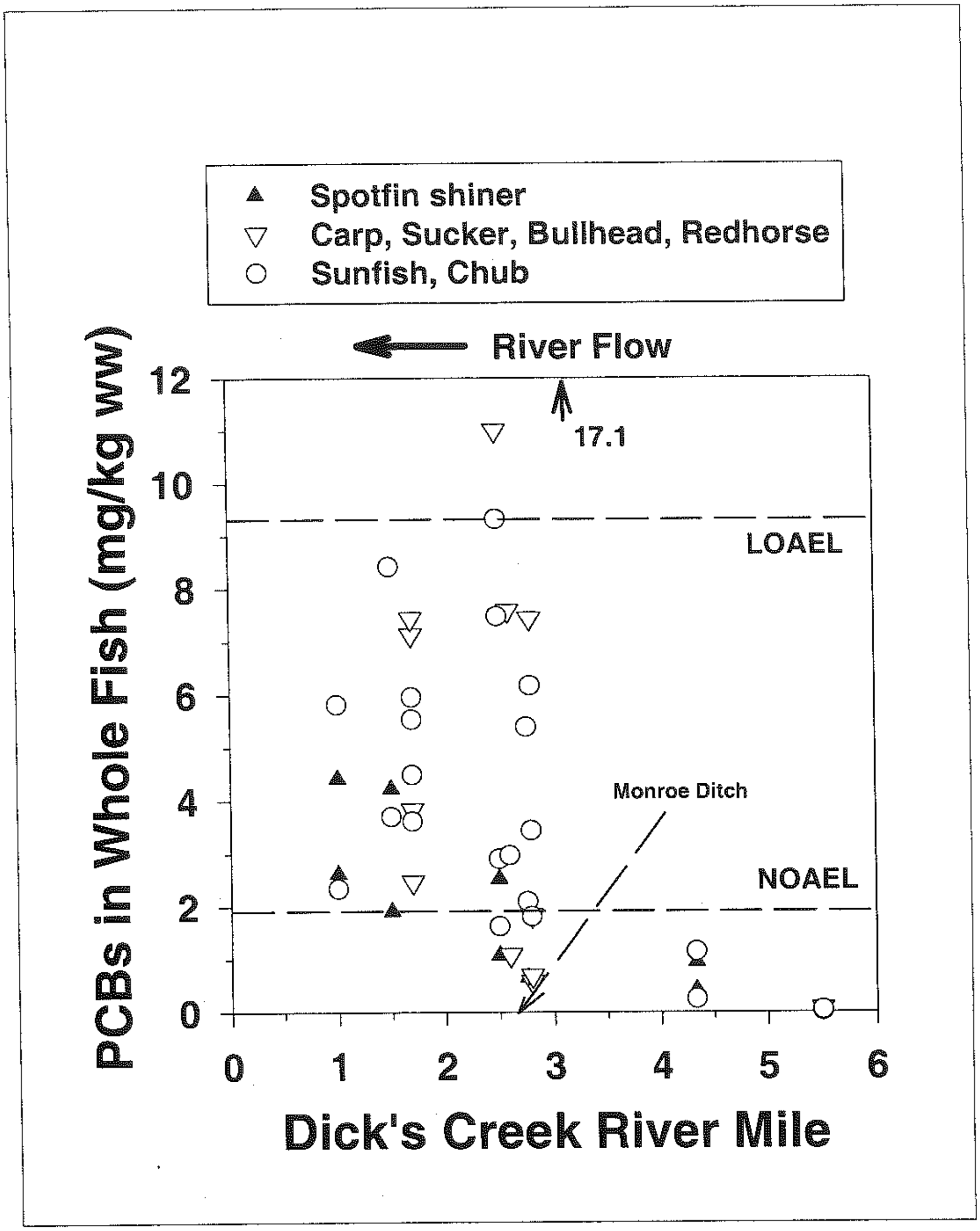

Figure 6.2. Comparison of whole body fish tissue concentrations to tissue-based TRVs for fish collected between 1999 and 2002. Data sources: Arcadis (2001a), OEPA (2000b), OEPA (2002). The NOAEL and LOAEL are critical body residue TRVs from Table 25a of EPA (2000). The arrow indicates the PCB concentration of 17.1 mg/kg (redhorse; Table F4-3) is off scale.

The available lines of evidence show that fish are likely at risk from total PCBs that have been released into Dick's Creek from the AK Steel site. This conclusion is considered to be of high confidence because the spatial extent of PCB bioaccumulation has been well characterized in fish, and risks were determined using TRVs indicative of adverse effects on a variety of fish species.

6.3.4 Amphibians and Reptiles

PCB risks to amphibians and reptiles were not assessed in the BERA because of limited information on the toxicity of PCBs to these receptors. Standard ecological risk assessment practice is to consider sensitive and exposed receptors (e.g., fish, wildlife) that are quantitatively assessed to be surrogates for amphibians and reptiles. Critical body residue data from Savage et al. (2002) suggest that amphibian tadpoles may have similar sensitivity as fish to tissue concentrations of total PCBs.

6.3.5 Soil Invertebrates and Plants

Soil invertebrates and plants were not considered to be at risk from total PCBs in Dick's Creek floodplain soil based on the initial risk screening (Section 2; Table A6-1, Appendix A). Terrestrial organisms were quantitatively evaluated as exposure pathways to wildlife.

6.3.6 Herbivorous Wildlife

Herbivorous wildlife (e.g., muskrat) were not considered to be at risk from total PCBs in aquatic plants in Dick's Creek based on the initial risk screening (Section 2; Table A1, Appendix A).

6.3.7 Piscivorous Wildlife

Risks to piscivorous wildlife were quantitatively estimated for three wildlife species:

- **Kingfisher.** The kingfisher feeds on fish and aquatic invertebrates, has a relatively small home range. TRVs were representative of the sensitivity of a range of bird species (USEPA, 2000). Kingfishers were not at risk from total PCBs (Table 6.3) but were at high risk from ingestion of dioxin-like PCB congeners (Table 6.8). LOAEL HQs based on consumption of aquatic organisms contaminated with dioxin-like PCBs ranged from 0.5 to 35.6, with a probability of exceeding ingestion TRVs of 99% (Table 6.8). The differences in total PCB and dioxin-like PCB risks resulted from the sensitivity of birds to the dioxin-like toxicity of PCBs that can exhibit higher relative bioaccumulation in aquatic prey. Figure 6.3 provides an additional line of evidence that kingfishers may be at risk. Multiple downstream locations exceed LOAELs (1.6 to 5.2 mg/kg) for total PCBs in sediment that were derived for colony nesting piscivorous birds for the Green Bay BERA (Figure 6.4; RETEC, 2002). The weight of evidence indicates that kingfishers are at risk from PCBs that have been released into Dick's Creek from the AK Steel site.

- **Raccoon.** Raccoons primarily feed on aquatic invertebrates and non-river sources of food. Raccoon TRVs were representative of the sensitivity of a range of mammalian species that are less sensitive than mink (USEPA, 2000). Raccoons were not at risk from either total PCBs (Table 6.4) or ingestion of dioxin-like PCB congeners in aquatic prey (Table 6.8). Raccoons that also feed in the Dick's Creek floodplain were at higher risk than those only feeding on aquatic prey, but the probability of risk was low. Raccoons were estimated to be at less risk than kingfisher and mink because of a larger home range, lower sensitivity, and lower intake of contaminated aquatic prey in the Dick's Creek system.

- **Mink.** Mink feed on fish, benthic invertebrates, and non-river sources of food, and are known to be highly sensitive to PCBs. Probabilistic risk estimates indicate that mink are at risk from total PCBs in the Dick's Creek system, with greater than 99% exceedences of LOAEL TRVs. Mink are also at risk from dioxin-like PCB congeners with a 90% probability of exceeding ingestion TRVs (Table 6.8). Multiple downstream locations exceed the LOAEL (0.24 mg/kg) for total PCBs in sediment that were derived for the protection of mink in the Green Bay BERA (Figure 6.4; RETEC, 2002). Additionally, there was a 95% probability of exceeding a less conservative dietary LOAEL TRV of 0.08 mg/kg*d derived from the mink feeding study of Brunstrom et al. (2001). The conclusion of substantial risks to mink is considered to be of high confidence because of the high probability of exceeding TRVs indicative of potential population-level effects.

Table 6.8. Ranges of Exposure and Risks of Dioxin-Like PCB Congeners to Wildlife.[1]

Receptor	TEC[2]	TRV	Hazard Quotient	% Exceedences[3]
Kingfisher	7.32 - 499 (ng/kg*d)	NOAEL - LOAEL	0.663 - 346	99.8%
		LOAEL	0.523 - 35.6	99.2%
Raccoon	0.016 - 3.47 (ng/kg*d)	NOAEL - LOAEL	0.002 - 2.65	2.17%
		LOAEL	0.002 - 0.347	<1%
Mink	0.260 - 37.9 (ng/kg*d)	NOAEL - LOAEL	0.149 - 420	96.3%
		LOAEL	0.116 - 16.9	89.9%

1. HQs are estimated for each category of TRV. The range of HQs is determined from probabilistic calculations of the ratio of (1) the probability distribution of dioxin-like PCB exposure as TEC and (2) the probability distribution of the NOAEL and the LOAEL. See Section 4 for discussion of TECs; see Table 5.1 for TRVs.
2. Dietary intake of dioxin-like PCB congeners as TECs; see Section 4.
3. The percentage of HQs that exceed a value of 1.

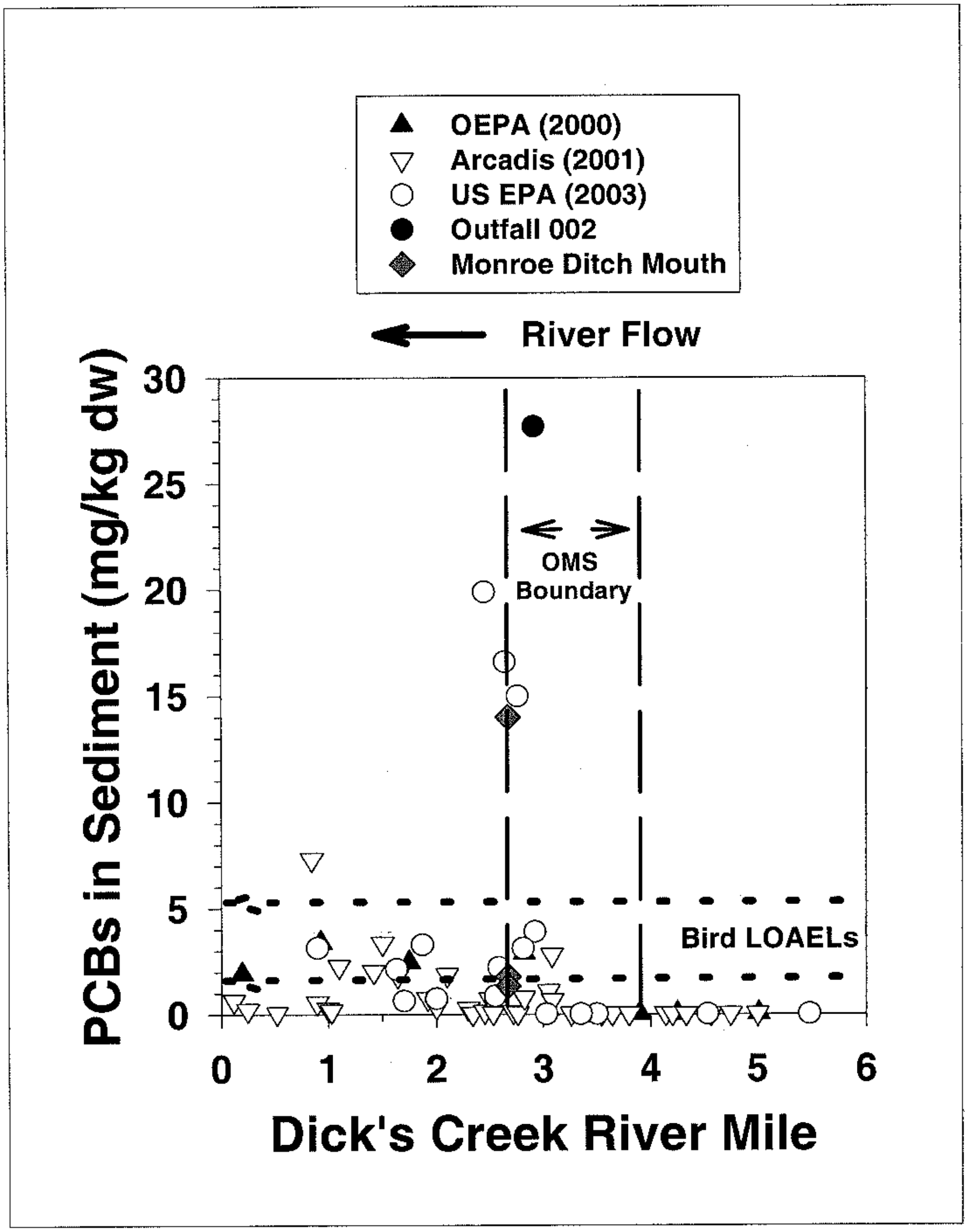

Figure 6.3. Total PCBs in surface sediment in Dick's Creek compared to LOAEL sediment quality thresholds for colony nesting piscivorous birds from RETEC (2002).

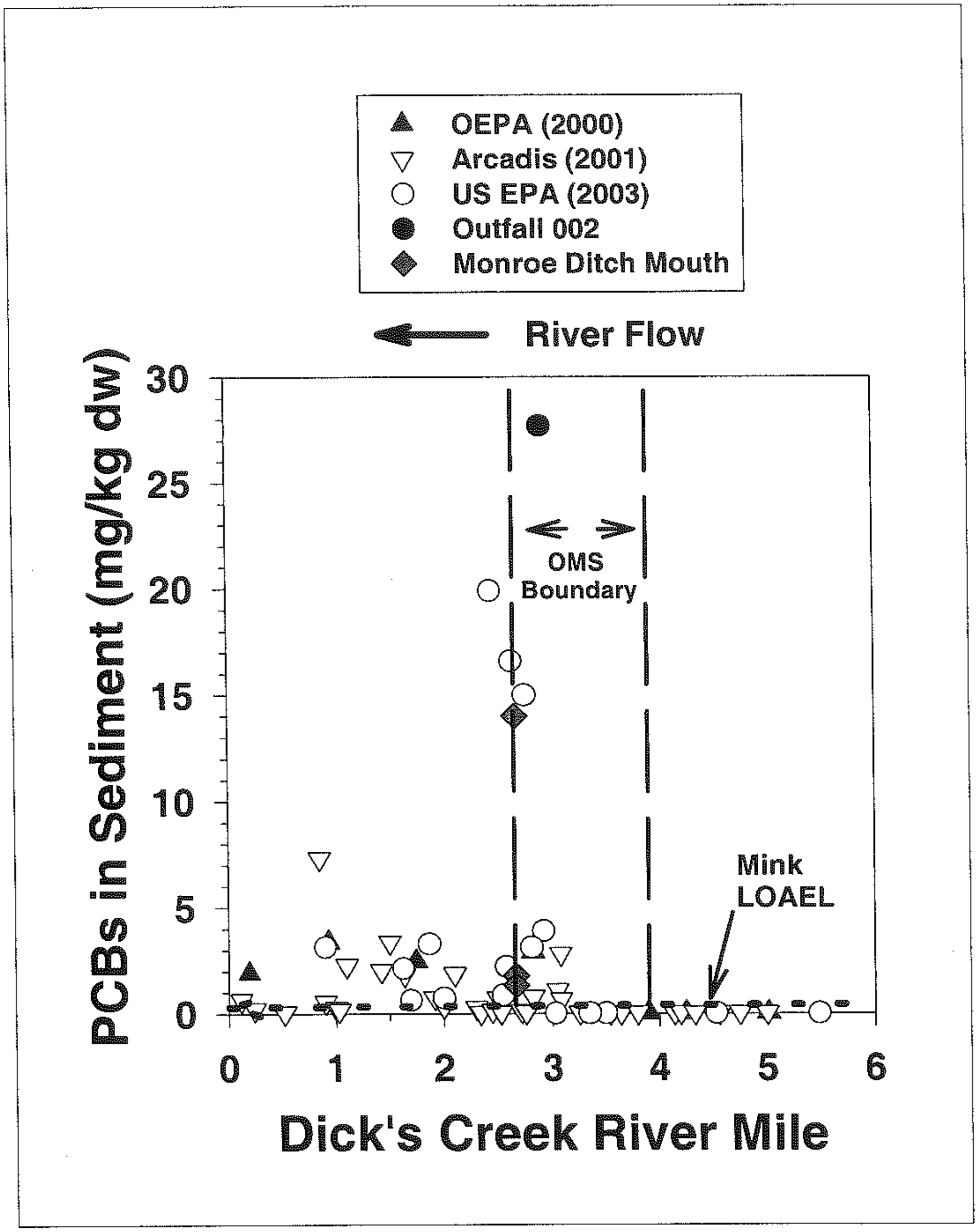

Figure 6.4. Total PCBs in surface sediment in Dick's Creek compared to the LOAEL sediment quality threshold for mink from RETEC (2002).

6.3.8 Terrestrial Wildlife

Risks to terrestrial wildlife were quantitatively estimated for two wildlife species:

- **American Robin.** The robin is representative of wildlife that has a relatively small home range and can be exposed to PCBs from consumption of earthworms and other soil organisms. Robins were assumed to obtain 50.5% of their diet from PCB-contaminated earthworms and 49.5% of their diet from non-contaminated sources. Robins were at risk from total PCBs (Table 6.6) with a 10.8% probability of exceeding LOAEL TRVs. Risks to small mammals was not assessed but may be similar or lower than for robins. For example, Boonstra and Bowman (2003) reported there was no apparent impact on shrews living in floodplain areas of the Housatonic River, Massachusetts at average PCB concentrations of 38 mg/kg soil. The weight of evidence indicates that robins are at some risk from total PCBs that have been released into Dick's Creek system from the AK Steel site.

- **American Kestrel.** The kestrel is a representative wildlife predator that has a relatively small home range and can be exposed to PCB-contaminated small mammals and other prey. Kestrels were assumed to obtain 41.1% of their diet from PCB-contaminated small mammals and 58.6% of their diet from non-contaminated sources. Kestrels were determined to not be at risk from total PCBs (Table 6.7).

6.4 Uncertainty Analysis

The uncertainty analysis describes data gaps and uncertainties in the BERA, and the potential to under- or overestimate ecological risks in the Dick's Creek system.

6.4.1 Receptors and Exposure Pathways

Receptors and exposure pathways that were not quantitatively assessed in the BERA included sediment, surface water, and soil exposure to aquatic plants, amphibians, and reptiles. Exclusion of these pathways and receptors is an uncertainty in the BERA, and indicates the potential to underestimate site-related risks. However, the exposure pathways and aquatic and wildlife receptors that were assessed in the BERA are considered to be broadly representative of exposure and risks in the Dick's Creek system.

6.4.2 COPCs and Non-Detected Chemicals

Only detected chemicals were evaluated in the BERA and several COPCs were identified but were not quantitatively assessed. Because of the variety of analytes in sediment and surface water, and the large number of samples, the potential to underestimate site-related risks from non-detected and non-measured chemicals is likely small. Three halogenated compounds were identified as COPCs in the risk screening for sediment because of an absence of screening values, and 11 COPCs were identified in floodplain soil based on comparison to NOAELs. Risks were not assessed for these COPCs, which represents an uncertainty in the BERA. The potential to underestimate site-related risks is considered to be small because (1) the chemicals were either not screened or exceeded no effect benchmarks, and (2) they were not determined to be COPCs in other media. There was insufficient information to determine if the observed concentrations of the COPCs were site-related.

6.4.3 PCB Exposure and Effects

The majority of the PCB exposure data used in the BERA was total PCBs determined from an analytical comparison to commercial Aroclor mixtures. Aroclor-based measurements may either under- or overestimate PCB exposures and risks because the congener composition may change and may be enriched through degradation and bioaccumulation (Butcher et al., 1997; Leonards et al., 1997). Congener-specific PCB analyses are considered to be a more accurate method for estimating total PCB concentrations, and a more accurate approach for assessing the ecological risks of PCBs than either an Aroclor- or homolog-based approach (USEPA, 2003c). Figure 6.5 suggests that total PCB concentrations in the Dick's Creek system may be underestimated using Aroclor-based quantitation methods. An underestimation of total PCB exposure concentrations would result in an underestimation of risks to ecological receptors.

A general data gap in the BERA is the limited data on concentrations of dioxin-like PCB congeners in the Dick's Creek system. Dioxin-like PCBs in prey fish were estimated from large fish fillets, which represents an uncertainty that was incorporated into the probabilistic risk assessment using TECs. In general, risks may be underestimated from a total PCB assessment (Barron et al., 1994; USEPA, 2000) because the dioxin-like PCBs may exhibit greater bioaccumulation and toxicity. An additional uncertainty is the assessment of dietary risks of dioxin-like PCBs to birds using TEFs primarily derived from the toxicity of PCBs to bird embryos. For the purposes of this risk assessment, the bird TEF values were considered more appropriate for assessing bird dietary risks of dioxin-like PCBs than mammal TEFs. Overall dioxin-like PCB risks are more likely to be underestimated, rather than over estimated for the following reasons:

- Dioxin-like PCB risks to piscivorous wildlife only included consumption of contaminated fish. Inclusion of ingestion of benthic invertebrates and incidental sediment ingestion would increase exposure and calculated risks from dioxin-like PCBs.

- Dioxin-like PCB risks to terrestrial wildlife were not evaluated in the BERA. The Dick's Creek floodplain is known to be contaminated with dioxin-like PCBs (USEPA, 2003a) and dioxin-like PCB risks may be substantially higher than determined from a total PCB-based assessment.

6.4.4 PCB Risk Characterization

Risks were estimated from probability distributions of HQs that incorporated the variability and uncertainty in exposure and toxicity of PCBs. Overall risks are more likely to be underestimated than overestimated because (1) only surficial (e.g., 0 to 1 foot) soil and sediment data were used (subsurface PCB contamination was not used to estimate future risks), (2) risks were primarily based on LOAEL TRVs, (3) risks of dioxin-like PCB risks were only assessed for fish and piscivorous wildlife, and (4) several PCB exposure pathways were not quantitatively assessed.

6.4.5 Background PCB Risks

Background risks were assessed using extremely conservative parameters, including maximum detected concentrations of total PCBs and NOAEL TRVs (Table 6.9). Background risks of PCBs appear to be low or non-existent in the Dick's Creek system, as evidenced by non-detections or very low contamination measured in surface water, sediment, aquatic plants, benthic invertebrates, and fish sampled upstream of apparent AK Steel PCB source areas (Table 6.9)

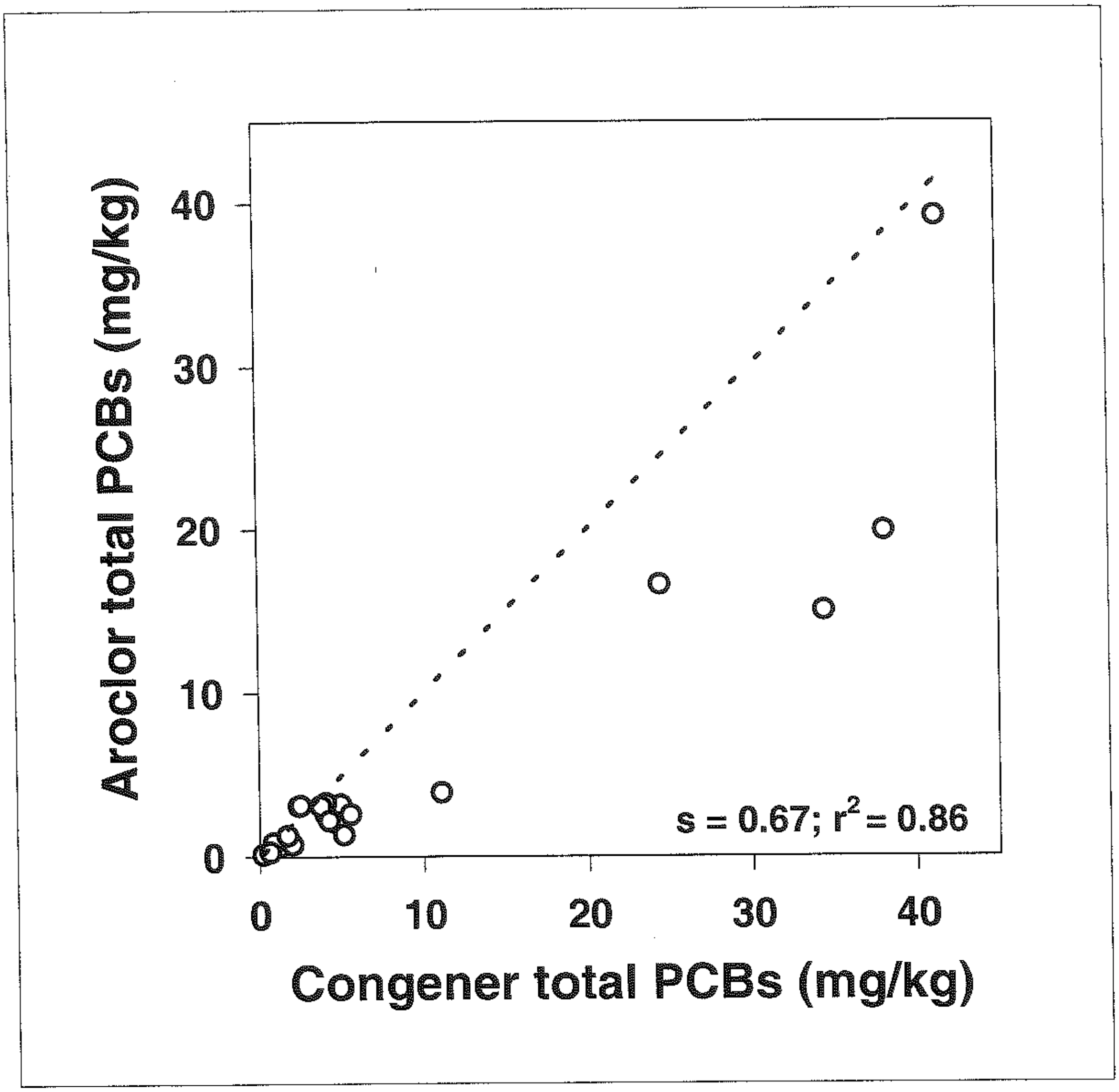

Figure 6.5. Total PCB concentrations in sediment samples from USEPA (2003a) were determined using congener-specific or Aroclor-based quantitation methods. Dashed line shows equivalent concentrations (i.e., slope = 1) and points below the line indicate PCB concentrations that are underestimated by the Aroclor-based method [slope (s) = 0.67]. r^2: coefficient of determination; correlation between congener-specific and Aroclor-based PCB methods.

Table 6.9. Screening of Background Risks of Maximum Concentrations of Total PCBs to Ecological Receptors in Media and Biota Sampled in Background Areas[1]				
PCB Exposure	**Maximum Total PCBs**	**NOAEL Screening Value[4]**	**Hazard Quotient**	**Risks Present?**
Surface water	ND[2]	14 ng/L[a]	ND[2]	ND[2]
Surface sediment	0.01 mg/kg dw 1% OC	0.035 mg/kg dw[b]	< 1	No
Floodplain surface soil	ND[3]	0.0003 mg/kg dw[c] 70 mg/kg dw[d]	NC[3]	No[3]
Aquatic plants	ND[2] (0.017 mg/kg ww)	0.071 mg/kg ww[e]	< 1	No
Benthic invertebrates	ND[2] (0.02 mg/kg ww)	0.071 mg/kg ww[e]	< 1	No
Fish	1.15 mg/kg ww	kingfisher: 4.6 mg/kg*d ww[f]	< 1	No
		raccoon: 2.0 mg/kg*d ww[f]	< 1	No
		mink: 0.028 mg/kg*d ww[f]	> 1	No[5]

1. Data and data sources are provided in Appendix F. Background areas are defined in Section 4.9.
2. PCBs were not detected; reported detection limits ≥100 ng/L. PCBs not detected in background areas in AquaQual (2001) at an estimated detection limit of 0.72 ng/L (BAH, 2002).
3. Not detected; no detection limit reported in Arcadis (2002a). Background risks of PCBs in floodplain surface soil considered minimal because of non-detected concentrations in background areas and low detections upstream of apparent facility source areas [e.g., <0.2 mg/kg; Arcadis (2002a)]; also inspection of Table A6-1 indicates floodplain surface soils would have to exceed 0.067 mg/kg dw soil to exceed no effect screening levels in prey (0.07 mg/kg ww) and 0.67 mg/kg dw soil to exceed lowest effect concentrations in prey (0.7 mg/kg ww).
4. Screening value source listed by footnote (see Appendix A for details; see text for acronyms): (a) AWQC from EPA (2002); (b) threshold effect concentration from MacDonald et al. (2000b); (c) EDQL from USEPA (1999c); (d) threshold effect concentration from Meier et al. (1997); (e) lowest NOAEL from Sample et al. (1996); (f) Estimated by food web exposure modeling assuming 100% consumption of fish using EPA (2000) NOAELs for kingfisher, raccoon, and mink. See Table 5.1.
5. Risks not considered significant because (1) maximum concentrations and NOAEL screening values used, (2) worst case exposure assumptions used (100% fish consumption and 100% area use), (3) fish are mobile and may reflect downstream PCB exposures, (4) data from Arcadis (2001a; Table B-11) indicate possible quality control concerns with the PCB concentrations, and (5) the most recent fish sampling (OEPA, 2002b) in background areas indicate substantially lower PCB levels in background areas than past concentrations reported by Arcadis (2001a).

6.4.6 Future Risks

Current risks in the Dick's Creek system were assessed using the 1999 or more recent exposure data described in Section 3, but future risks were not assessed. Two lines of evidence suggest that future risks of PCBs will be similar to current risks unless PCBs are remediated in the Dick's Creek system:

(1) There has been no apparent decline in PCBs in the Dick's Creek system since 1999 based on the data evaluated in this BERA.

(2) PCBs are present in surface and subsurface sediments and floodplain soil, providing a potential source of future biological exposures through flood and resuspension.

7. Summary and Conclusions

7.1 Summary of the BERA

This report assesses the risks of AK Steel site contaminants to ecological receptors using and inhabiting the Dick's Creek system. A BERA was performed according to current USEPA guidance, including problem formulation, analysis of exposure and effects, and risk characterization (USEPA, 1997, 1998, 2001). The initial risk screening was performed in the Problem Formulation section of the BERA and corresponded to Step 3 of the USEPA (1997) ecological risk assessment process. A screening-level ERA [Steps 1 and 2 of the USEPA (1997) risk process] was not performed because the potential for ecological risks had already been identified in two previous risk assessments.

<u>Problem Formulation</u>

Dick's Creek is a stream in southwest Ohio that has received PCB and other contaminant releases from the AK Steel site in Middletown, Ohio. Dick's Creek generally flows east to west to its confluence with the Great Miami River (river mile 0) and is in proximity to the AK Steel site from approximately river miles 2.5 to 5.5. Monroe Ditch is a stream and not a ditch. The June 2002 site visit by Dr. Barron showed that Monroe Ditch had flowing water with multiple pools and riffles, a well-developed riparian area, and a meandering stream channel.

A HQ approach was used to identify COCs using a systematic and moderately conservative screening process of comparing maximum detected contaminant concentrations and LOAEL screening values. EPCs were calculated for detected contaminants using only data collected since 1999 because they were considered to be most representative of current conditions. EPCs were determined in media (surface water, sediment, floodplain soil) and biota. Non-detected analytes were excluded from consideration because of the extensive analytical data set for surface water and sediment, and the need to focus the BERA on the most likely risk drivers. Wildlife risks were determined using measured (aquatic) or estimated (terrestrial) prey concentrations. Mink, raccoon, belted kingfisher, American robin, and American kestrel were selected as wildlife receptors because they are highly exposed (consume contaminated media and biota; have small home ranges), are sensitive to PCBs (particularly mink), and exposure parameters and TRVs were available (USEPA, 1993; USEPA, 2000).

PCBs were identified as the only COC in Dick's Creek for the following receptors and exposure pathways: (1) benthic invertebrate contact with sediment, (2) fish contact with surface water and accumulation of toxic body residues, (3) piscivorous wildlife ingestion of benthic invertebrates, fish, and sediment (incidental), and (4) terrestrial wildlife ingestion of soil invertebrates and small mammals, and soil (incidental). Aquatic plants, soil invertebrates and plants, and herbivorous wildlife were determined to not be at risk from PCBs in the initial risk screening, and are qualitatively evaluated in the uncertainty analysis. Relatively few COPCs were identified in floodplain surface soil and surficial sediment in the risk screening and were qualitatively evaluated in the uncertainty analysis.

Analysis of PCB Exposure and Effects

Only data from 1999 or more recent for sediment, groundwater seeps, floodplain soils, and biota were used because these data were considered to be most representative of current conditions. Data were obtained from three sources: AK Steel/Arcadis, OEPA, and USEPA. Only surficial sediment and floodplain soil data were considered in this BERA, and sediment PCB concentrations of PCBs were normalized to 1% OC for the assessment of risks to benthic invertebrates.

Multiple AK Steel sources of PCBs exist along the site boundary, including contaminated groundwater seeps, Outfall 002 sediments, in-place sediments in Dick's Creek, and Monroe Ditch. The available data consistently show that PCBs substantially increase in sediment, aquatic plants, benthic invertebrates, and fish downstream of these source areas. PCBs are low or not detectable upstream of these areas. PCB contamination has been detected for over three miles in Dick's Creek to nearly its confluence with the Great Miami River, and the available recent data (1999 to 2003) do not show any apparent declines in PCB concentrations.

Two categories of TRVs from USEPA (2000), USEPA (2002), and MacDonald et al. (2000) were used in quantifying PCB risks: (1) a uniform range of NOAEL and LOAEL TRVs, and (2) the LOAEL.

Risk Characterization

A probabilistic assessment was used to estimate total PCB risks to benthic invertebrates, fish, and piscivorous and terrestrial wildlife. A probability distribution of hazard quotients was determined from the variability and uncertainty in exposure and toxicity, and provided directly interpretable risk descriptions for risk managers. The following ecological receptors were determined to be at risk from PCBs in the Dick's Creek system: benthic invertebrates, mink, and piscivorous and terrestrial birds. PCBs may also pose risks to fish. Risks are described in detail for each category of ecological receptor in Section 7.2 by addressing the risk questions posed in Table 2.2.

Background risks appear to be negligible in Dick's Creek, as evidenced by non-detections or very low contamination measured in sediment, aquatic plants, benthic invertebrates, and fish upstream of AK Steel PCB source areas.

Uncertainty Analysis

The principal uncertainty in the BERA was that the assessment was primarily based on total PCBs, which may result in an over- or underestimation of ecological risk. Risks were more likely underestimated for both total PCBs and dioxin-like PCB congeners because (1) the majority of total PCB data were determined using analytical methods that may underestimate total PCB concentrations in Dick's Creek, and (2) dioxin-like PCB exposure and risks were not assessed for a number of ecological exposure pathways because of limited data. Secondary sources of uncertainties include the spatial extent of PCB contamination in the Dick's Creek floodplain, the risks to plants and soil invertebrates, the risks of non-detected chemicals, and the relatively few COPCs.

7.2 Risk Questions

This section evaluates each of the risk questions presented in Table 2.2.

Are site contaminants in sediments causing risks to benthic invertebrates?

The weight of evidence indicates that PCBs in sediments in the Dick's Creek system are causing risks to benthic invertebrates downstream of AK Steel source areas of PCBs. The evidence includes a high probability of exceeding medium and severe effects levels, and indications that the benthic invertebrate community is impaired and sediments are toxic downstream of the AK Steel site.

Are site contaminants in surface water causing risks to fish and water column invertebrates?

The weight of evidence indicates that PCBs may cause risks to fish in the Dick's Creek system downstream of AK Steel sources of PCBs. The evidence includes a 6% (LOAEL) and 30% (NOAEL-LOAEL) probability of fish bioaccumulating critical body residue levels of PCBs.

Are site contaminants in forage and prey causing risks to piscivorous wildlife?

A probabilistic assessment of risks indicates that PCBs are causing risks to mink downstream of AK Steel source areas of PCBs. Kingfishers were determined to be at risk from dioxin-like PCBs (99% probability of risks) but not from total PCB concentrations. This risk conclusion is considered to be of high confidence because dioxin-like PCB risks to kingfishers may be higher than estimated. Only risks of consumption of contaminated fish were evaluated and inclusion of ingestion of benthic invertebrates and incidental sediment ingestion would increase exposure and calculated risks from dioxin-like PCBs. Risks to raccoons were estimated to be low. PCBs increase in the forage and aquatic prey of wildlife (aquatic plants, benthic invertebrates, fish) downstream of the AK Steel site, and the highest levels of PCBs in fish are present in or in close proximity to the natural portions of Dick's Creek. Risks to wildlife may be underestimated because PCB exposure in piscivorous wildlife may be higher in the natural sections of Dick's Creek where wildlife may preferentially feed. The magnitude of PCB risks and the spatial extent of contamination indicate that mink feeding in the Dick's Creek system would not be able to successfully reproduce. The Dick's Creek system likely provides mink habitat based on the natural stream areas that exist downstream of the AK Steel site (USFS, 2002), which is consistent with previous statements regarding mink habitat in Arcadis (2001a). Mink are considered to be common statewide in Ohio (ASM, 1999).

Are site contaminants in forage and prey causing risks to terrestrial wildlife?

A probabilistic assessment of risks indicates that PCBs are causing risks to robins downstream of

AK Steel source areas of PCBs, but kestrels are not at risk. Risks to terrestrial wildlife may be higher from dioxin-like PCBs than total PCBs, but adequate exposure data were not available.

7.3 Conclusions

PCB contamination is present in the Dick's Creek system in surface and subsurface sediments, floodplain soils, and aquatic organisms downstream of apparent AK Steel source areas. PCBs contaminate Monroe Ditch and Dick's Creek from approximately river mile 3 to near the confluence with the Greater Miami River (river mile 0). Aquatic organisms and wildlife are at risk from PCBs in the Dick's Creek system downstream of AK Steel site source areas of PCBs. In contrast, PCB levels are low or non-detectable in upstream areas and are unlikely to pose risks to aquatic organisms and wildlife. These conclusions are considered to be of high confidence and consider the variability and uncertainty in PCB exposure and toxicity. PCB risks in the Dick's Creek system are more likely to be underestimated than overestimated from the approach used in this BERA.

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Appendix A

Determination of Contaminants of Concern (COCs)

Overview

This Appendix summarizes the screening of contaminants detected by Arcadis (2001a, 2001b, 2001c, 2001d), OEPA (2000a,b), and USEPA (2003a, 2003b) to determine contaminants of concern (COCs) in the baseline ecological risk assessment (BERA). This process eliminates contaminants unlikely to pose significant risks and allows the BERA to focus on the most likely risk drivers. Risks are screened by media (surface water, sediment, floodplain soil) and biological tissue category below using maximum detected concentrations and lowest observed adverse effect level (LOAEL) screening values (listed in each table). Wildlife risks are screened by comparing detected or estimated contaminant concentrations in prey and forage (e.g., aquatic plants, benthic invertebrates, fish) to dietary toxicity screening values.

A1. Screening of Wildlife Risks from Measured Contaminants in Plants

Table A1. Maximum Detected Contaminant Concentrations in Aquatic Plants from Dick's Creek (mg/kg ww) Compared to Wildlife Screening Values (mg/kg ww)[1]

Analyte	Maximum Concentration	Source	Screening Value[2]	Hazard Quotient	COC?[4]
PCBs	0.284	Arcadis (2001a) Table B-5	0.71	<1	No
total PAHs	0.205	Arcadis (2001a) Table B-3	20[3]	<1	no
Cadmium	0.029	Arcadis (2001a) Table 3-6	16.6	<1	no
Chromium	0.44	Arcadis (2001a) Table 3-6	4.1	<1	no
Lead	1.1	Arcadis (2001a) Table 3-6	9.4	<1	no
Nickel	2.5	Arcadis (2001a) Table 3-6	89	<1	no
Silver	0.0068	Arcadis (2001a) Table B-4	NA[5]	NC[5]	no[5]
Zinc	20	Arcadis (2001a) Table 3-6	109	<1	no

1. Maximum detected concentration in available data sources.
2. Lowest of the LOAEL reported in Table 12 of Sample et al. (1996), unless otherwise noted.
3. Wildlife screening value derived in Appendix C.
4. COC if hazard quotient > 1.
5. Benchmark not available (NA) and hazard quotient not calculable (NC). Not considered a COC because all metal toxicity benchmarks generally exceed 1 mg/kg (i.e., silver unlikely to be toxic at detected level).

A2. Screening of Wildlife Risks from Measured Contaminants in Benthic Invertebrates

Table A2. Maximum Detected Contaminant Concentrations in Benthic Invertebrates from Dick's Creek (mg/kg ww) Compared to Wildlife Screening Values (mg/kg ww)[1]

Analyte	Maximum Concentration	Source	Screening Value[2]	Hazard Quotient	COC?[4]
PCBs	2.5	Arcadis (2001a) Table 3-7	0.71	3.5	yes
total PAHs	0.145	Arcadis (2001a) Table 3-8	20[3]	<1	no
Cadmium	0.023	Arcadis (2001a) Table 3-9	16.6	<1	no
Chromium	0.69	Arcadis (2001a) Table 3-9	4.1	<1	no
Copper	23	Arcadis (2001a) Table 3-9	51.1	<1	no
Lead	0.28	Arcadis (2001a) Table 3-9	9.4	<1	no
Nickel	2.0	Arcadis (2001a) Table 3-9	89	<1	no
Silver	0.105	Arcadis (2001a) Table B-7	NA[5]	NC[5]	no[5]
Zinc	23	Arcadis (2001a) Table 3-9	109	<1	no

1. Maximum detected concentration in available data sources.
2. Lowest of the LOAEL reported in Table 12 of Sample et al. (1996), unless otherwise noted.
3. Wildlife screening value derived in Appendix C.
4. COC if hazard quotient > 1.
5. Benchmark not available (NA) and hazard quotient not calculable (NC). Not considered a COC because all metal toxicity benchmarks generally exceed 1 mg/kg (i.e., silver unlikely to be toxic at detected level).

A3. Screening of Wildlife Risks from Measured Contaminants in Fish

Table A3-1. Maximum Detected Contaminant Concentrations in Whole Fish from Dick's Creek (mg/kg ww) Compared to Wildlife Screening Values (mg/kg ww)[1,5]

Analyte	Maximum Concentration	Source	Screening Value[2]	Hazard Quotient	COC?[4]
PCBs	8.415	Arcadis (2001) Table 3-10	0.71	11.9	yes
Dieldrin	0.005	OEPA (2000b)	0.74	<1	no
g-Chlordane	0.050	OEPA (2000b)	8.9	<1	no
total PAHs	0.196	Arcadis (2001) Table 3-10	20[3]	<1	no
Arsenic	0.0418	OEPA (2000b)	2.5	<1	no
Cadmium	0.037	OEPA (2000b)	16.6	<1	no
Chromium	1.0	Arcadis (2001) Table 3-9	4.1	<1	no
Copper	2.2	Arcadis (2001) Table 3-9	51.1	<1	no
Lead	0.133	OEPA (2000b)	9.4	<1	no
Mercury	0.0376	OEPA (2000b)	0.053[5]	<1	no
Nickel	0.82	Arcadis (2001) Table 3-9	89	<1	no
Selenium[5]	0.162	OEPA (2000b)	0.66[5]	<1	no
Zinc	83	Arcadis (2001) Table 3-9	109	<1	no

1. Excludes larger fish species (e.g., carp, sucker, bullhead, bass).
2. Lowest of the LOAEL reported in Table 12 of Sample et al. (1996), unless otherwise noted.
3. Wildlife screening value derived in Appendix C.
4. COC if hazard quotient > 1.
5. Screening value is for most toxic form of chemical (i.e., methylmercury, alkyl-selenium).

Table A3-2. Maximum Toxicity Equivalence Concentrations (TECs) of PCDDs/PCDFs in Fillets of Large Fish from Dick's Creek (ng/kg ww) Compared to Wildlife Screening Values (ng/kg ww)[1]					
Analyte[2]	**Maximum Concentration**	**Source**	**Screening Value[3]**	**Hazard Quotient**	**COC?**
Mammal TEC	5.89	EPA (2003b)	3.2	1.84	No[4]
Bird TEC	7.63	EPA (2003b)	116	< 1	No

1. PCDDs/PCDF concentrations in large fish fillets used as a surrogate for whole body small and medium sized fish for screening purposes only.
2. TEC were calculated from the sum of TEC calculated for each PCDD/PCDFs.
3. Lowest of the LOAEL values for 2,3,7,8-tetrachloro dibenzo-p-dioxin (TCDD) reported in Table 12 of Sample et al. (1996).
4. Not considered a COC because of low magnitude of exceedences of mammalian TCDD screening value; no exceedences of eight other TCDD screening values in Sample et al. (1996).

A4. Screening of Benthic Invertebrate Risks from Measured Contaminants in Sediment

Table A4-1. Maximum Detected Contaminant Concentrations in Sediment from Dick's Creek (mg/kg dw) Compared to Sediment Screening Values (mg/kg dw)

Analyte	Maximum Concentration	Source	Screening Value[2]	Hazard Quotient	COC?[4]
PCBs	52.1[1]	Arcadis (2001a) Table 5-1	0.676	77	yes
total PAHs	13.5[1,3,13]	EPA (2003a)	22.8	<1	no[3]
g-chlordane	0.0465	OEPA (2000a)	17.6[5]	<1	no
Aldrin	0.0005	OEPA (2000a)	40[5]	<1	no
2,4,6-tribromophenol	7.81[10]	EPA (2003a)	NA[11]	NA[11]	COPC[11]
2-fluorobiphenyl	4.81[10]	EPA (2003a)	NA[11]	NA[11]	COPC[11]
2-fluorophenol	4.54[10]	EPA (2003a)	NA[11]	NA[11]	COPC[11]
Arsenic	13.8	OEPA (2000a)	33	<1	no
Aluminum	14,950	Arcadis (2001a) Table 3-2	25,500[5]	<1	no
Barium	100	OEPA (2000a)	NA[9]	NC[9]	no[9]
Cadmium	1.27[6]	Arcadis (2001a) Table 3-2	4.98	<1	no
Chromium	129	Arcadis (2001d) Appendix C	111	1.2	no[12]
Copper	65.1	Arcadis (2001a) Table 3-2	149	<1	no
Iron	30,500	OEPA (2000a)	40,000[5]	<1	no
Lead	62[6]	Arcadis (2001a) Table 3-9	128	<1	no
Manganese	760	OEPA (2000a)	630	1.2	no[7]
Mercury	0.073	OEPA (2000a)	1.06	<1	no

Table A4-1. Maximum Detected Contaminant Concentrations in Sediment from Dick's Creek (mg/kg dw) Compared to Sediment Screening Values (mg/kg dw)					
Analyte	**Maximum Concentration**	**Source**	**Screening Value**[2]	**Hazard Quotient**	**COC?**[4]
Nickel	33.1	Arcadis (2001a) Table 3-2	48.6	<1	no
Silver	0.3	Arcadis (2001a) Table 3-2	4.5[5]	<1	no
Strontium	247	OEPA (2000a)	NA[9]	NC[9]	no[9]
Titanium	61.7	OEPA (2000a)	NA[9]	NC[9]	no[9]
Zinc	664	OEPA (2000a)	459	1.4	no[8]

1. Normalized to 1% OC content for screening of risks to benthic invertebrates.
2. Screening values are probable effects concentrations from MacDonald et al. (2000a).
3. Sum of detected polycyclic aromatic hydrocarbon (PAH) analytes. Excludes one sample in Outfall 002 (62.3 mg/kg at 1% OC). All other OC normalized samples (or average of sample duplicates) were below the maximum value reported in this Table.
4. COC: contaminant of concern if hazard quotient > 1.
5. Lowest freshwater screening value in NOAA (1999).
6. Reported as simultaneously extracted metal (SEM; reported total metal values are higher). Highest total lead reported in OEPA (2000) 38.3 mg/kg.
7. Not considered a COC because only one detection exceeded screening value (River Mile 0.93) and hazard quotient near 1.
8. Not considered a COC because only two detections exceeded screening value (River Mile 0.93 and 5.01) and both hazard quotients near 1. Maximum Arcadis (2001) SEM value was below screening value.
9. Benchmark not available (NA) and hazard quotient not calculable (NC). Not considered a COC because shows minimal exceedences of marine threshold (HQ 2.08).
10. Average of samples S11 and D33.
11. Identified as a COPC (contaminant of potential concern) because of exceedences of NOAEL screening value (or NA: no EDQL available).
12. Not considered a COC because of minimal exceedences in an Outfall 003 sample; other samples below screening value.
13. Arcadis surface soil sample ARC0351.D (USEPA location S01) had a total PAH concentration of 16 mg/kg 1% OC which was below the screening value (Arcadis data reported in September 11, 2003 data transmittal from P.W. Casper to R.W. Darnell; Excel data: MS10758-Seds-PAH-final).

Table A4-2. Maximum TEC of PCDDs/PCDFs in Sediment from Dick's Creek (ng/kg ww) Compared to a Sediment Screening Value (ng/kg ww)[1]					
Analyte[2]	**Maximum Concentration**	**Source**	**Screening Value[3]**	**Hazard Quotient**	**COC?**
PCDDs/PCDFs TEC	20.0	EPA (2003a)	8.8	2.3	No[2]

1. PCDDs/PCDFs data from EPA (2003a).
2. Total TECs were calculated from the sum of TEC calculated for each PCDD/PCDFs using fish toxicity equivalency factors. Applicability of benchmark to benthic invertebrates is uncertain and likely represents overly conservative screening value; i.e., PCDDs/PCDFs may have substantially lower potency in benthic invertebrates in fish.
3. Screening value from NOAA (1999).

A5. Screening of Aquatic Life Risks from Measured Contaminants in Surface Water

Table A4. Maximum Detected Contaminant Concentrations in Surface Water from Dick's Creek (μg/L) Compared to Surface Water Screening Values (μg/L)[1,8]

Analyte	Maximum Concentration	Source	Screening Value[2]	Hazard Quotient	COC?[4]
PCBs	ND[5]	ND[5]	0.014	ND[5]	ND[5]
total PAHs	<1	Arcadis (2001) Table B-1	analyte-specific[7]	<1	no
Aluminum	8	Arcadis (2001) Table B-1	75[6]	<1	no
Arsenic[3]	6	OEPA (2000c)	150	<1	no
Barium[3]	137	OEPA (2000c)	3.8[6]	>1	no[9]
Cadmium	0.09	Arcadis (2001) Table 5-4	2.2	<1	no
Chromium[3]	2.0	Arcadis (2001) Table 5-4	11	<1	no
Copper	1.95	Arcadis (2001) Table 5-4	9	<1	no
Iron	38.6	Arcadis (2001) Table B-1	158[6]	<1	no
Lead	0.57	Arcadis (2001) Table 5-4	2.5	<1	no
Manganese[3]	273	OEPA (2000c)	80.3[6]	>1	no[9]
Nickel	14.7	Arcadis (2001) Table 5-4	52	<1	no
Silver	0.047	Arcadis (2001) Table B-1	0.12[6]	<1	no
Strontium[3]	1,020	OEPA (2000c)	620[6]	>1	no[9]
Zinc	24.5	Arcadis (2001) Table 5-4	120	<1	no

Table A4. Maximum Detected Contaminant Concentrations in Surface Water from Dick's Creek (μg/L) Compared to Surface Water Screening Values (μg/L)[1,8]

1. Metals concentrations are dissolved if available; total concentrations noted where listed.
2. Screening values are freshwater AWQC (USEPA, 2002) unless otherwise noted. Metal benchmarks were not corrected for water hardness for the screening because no detected concentrations exceeded more conservative default AWQC values.
3. Total detected concentration (dissolved concentration not reported). Chromium screening value is for hexavalent chromium.
4. COC if hazard quotient > 1, unless rationale provided for exclusion.
5. Multiple non-detections at detection limits of 0.1 to 0.2 μg/L.
6. Lowest value reported by Suter (1996).
7. Screening value for total PAHs not available. Comparison of individual analytes or homolog groups to Suter (1996) screening values indicates all hazard quotients <1.
8. Excludes a few low level ($\leq$10 μg/L) detections of organic analytes by OEPA (2000c) because of unknown toxicity and inconsistent detections: acetone, thiazoles, propanols, butanols, ethanols, propanal, butanal, heptanal, octadecenal, 2,3H-benzothiazolone, squalene, vitamin E, phenols, 1,3-dihydro-2H-indol-2-one, hexanoic acid, decanoic acids and esters, nitriles, o-hydroxybiphenyl, chloroform, phytol, 1-octadecene, 2-butanone, bromodichloromethane, nonanoic acid, xylenes, phthalates, oxetanone, and acetaldehyde. Pesticides were detected at less than 0.01 μg/L: BHCs, endosulfan, hexachlorobenzene, endrin, and heptachlors. A few chemicals were infrequently detected at greater than 10 μg/L: 2-butoxyethanol (20 μg/L), one decanoic acid (30 μg/L), and a compound listed as benzo[1,2-c:3,4-c':5,6-c"]tris[1,3,5]ox ($\leq$80 μg/L). These chemicals were considered to be at low levels and not site related. Also excludes two low detections of phthalic acid esters in EPA (2003a) that are considered to be sampling artifacts.
9. Not considered a COC for quantitative evaluation because reported concentration is a total rather than dissolved measurement. Discussed in the uncertainty section.

A6. Screening of Wildlife Risks from Measured Contaminants in Floodplain Soil

Table A6-1. Screening of Risks to Ecological Receptors Using Maximum Detected Contaminant Concentrations of PCBs in Surface Soil of the Dick's Creek Floodplain.[1]

Receptor	Prey	PCBs in Soil (mg/kg dw)	BAF	Prey PCBs (mg/kg dw)	Prey PCBs (mg/kg ww)[4]	Screening Value (mg/kg ww)	Hazard Quotient
Wildlife	earth-worm	39.2	6.67[2]	261[3]	41.8	0.71[5]	58.9
	small mammal	39.2	0.76[6]	NA[6]	29.9	0.71[5]	42.1
Plants, earth-worms	NA	39.2	NA	NA	NA	70[7]	< 1

1. Maximum soil concentration from Table G3-1. NA: not applicable.
2. BAF: soil to earthworm bioaccumulation factor (dw earthworm:dw soil). Median value for combined data set from Sample et al. (1999).
3. Prey PCBs = soil PCBs*BAF.
4. Conversion of dw prey PCBs to ww prey PCBs assuming moisture content of earthworms of 84% (Sample et al., 1999). PCB ww = PCB dw*0.16.
5. See Table A1.
6. BAF: soil to small mammal bioaccumulation factor (ww mammal:dw soil). Median value for omnivore category from Sample et al. (1998). TCDD value used as a surrogate. NA: not applicable (BAF converts prey to ww PCBs).
7. Screening value determined from Meier et al. (1997).

Table A6-2. Screening of Risks to Ecological Receptors Using Maximum Detected Contaminant Concentrations of Other Chemicals in Surface Soil of the Dick's Creek Floodplain[1]					
Chemical	**Sample Identification[1]**	**Soil level (mg/kg dw)**	**Screening Value (mg/kg dw)[2]**	**Hazard Quotient**	**COC?[3]**
Benzo(a)anthracene	S23	0.677	5.21	<1	no
Benzo(a)pyrene	S23	0.914	1.52	<1	no
Benzo(b)fluoranthene	S23	1.12	59.8	<1	no
Chrysene	S23	0.773	4.73	<1	no
Fluoranthene	S23	1.07	122	<1	no
Pyrene	S23	1.07	78.5	<1	no
Arsenic	S26	8.3	5.7	1.5	no[4]
Barium	S22	120	1	120	COPC[5]
Chromium	S26	16	0.4	40	COPC[5]
Copper	S26	21	0.313	67	COPC[5]
Iron	S22	25,000	NA[5]	NA[5]	COPC[5]
Lead	S29	41	0.054	763	COPC[5]
Magnesium	S29	23,000	NA[5]	NA[5]	COPC[5]
Manganese	S26	810	NA[5]	NA[5]	COPC[5]
Nickel	S26	23	13.6	1.7	no[4]
Tin	S23	62	7.62	8.1	COPC[5]
Titanium	S26	160	NA[5]	NA[5]	COPC[5]
Vanadium	S22	30	1.59	18.9	COPC[5]
Zinc	S27	300	6.62	45.3	COPC[5]

Table A6-2. Screening of Risks to Ecological Receptors Using Maximum Detected Contaminant Concentrations of Other Chemicals in Surface Soil of the Dick's Creek Floodplain[1]

1. Maximum soil concentration from EPA (2003a).
2. Screening values are ecological data quality levels (EDQLs) for soil from EPA (1999c), which are conservative no observed adverse effect levels (NOAELs).
3. COC if hazard quotient > 1, unless rationale provided for exclusion.
4. Not considered COC because of minimal Exceedences of NOAEL at maximum detected value.
5. Identified as a COPC because of exceedences of NOAEL screening value (or NA: no EDQL available). Uncertain whether the compound is a COC and whether it is facility related.

Appendix B

Wildlife Exposure Parameters

Overview

This Appendix lists the exposure model parameter used in assessing risks to wildlife. Only those pathways and wildlife receptors that were determined from the risk screening (Appendix A) are included: kingfisher, raccoon, mink, robin, kestrel. See report text for explanation.

B1. Kingfisher

Table B1. Ranges of Exposure Parameter Values for the Belted Kingfisher.[1]

Parameter	Symbol	Units	Range	Notes
Body weight	BW	kg (ww)	0.147	
Ingestion rate	IRwet	kg/d (ww)	0.058	
	IRdry	kg/d (dw)	0.017	
Water Consumption	WI	L/d	0.016	PCB water exposure concentration set at 0 mg/L.
Diet Composition	PD	%	fish: 78 AI[2]: 22	Alternative parameters used for calculating TEC exposure[5]
Incidental Sediment Ingestion	FS	%	1	Alternative parameter used for calculating TEC exposure[5]
Area Use Factor[3]	AUF	unitless	1	AH: 6.44 HR: 0.7 km
Exposure Duration[4]	ED[4]	unitless	1	

1. Values from Table 3-23 of USEPA (2000) unless indicated. All mass units in ww.
2. AI: aquatic invertebrates.
3. AUF calculated from the spatial extent of affected site habitat divided by species-specific home range: AUF = AH/HR. AH (affected habitat) determined from length of affected Dick's Creek (4 miles); see report Section 4; HR (home range) determined from USEPA (2000).
4. ED = sum of temporal correction factors in USEPA (2000).
5. Alternative parameters were used for calculating TEC exposure because of benthic invertebrate data for dioxin-like PCB congeners were not available in the chemistry data sources used in the BERA (Section 3). fish: 78; AI: 0; FS: 0.

B2. Raccoon

Table B2. Ranges of Exposure Parameter Values for the Raccoon.[1]

Parameter	Symbol	Units	Range		Notes
Body weight	BW	kg	6.4 - 7.6		Female - male
Ingestion rate	IRwet	kg/d	0.99 - 1.2		Female - male
	IRdry	kg/d	0.316 - 0.364		
Water Consumption[7]	WI	L/d	0.526 - 0.614		Female - male
Diet Composition	PD	%	**Scenario 1** Stream: fish: 3 AI[2]: 37 Floodplain:[6] small mammal: 0 earthworm: 0 No PCBs: NR[2]: 60	**Scenario 2** Stream: fish: 3 AI[2]: 37 Floodplain:[6] small mammal: 14.3 earthworm: 7.2 No PCBs: NR[2]: 38.5	Alternative parameters used for calculating TEC exposure[8]
Incidental Sediment Ingestion	FS	%	9.4		Alternative parameter used for calculating TEC exposure[8]
Area Use Factor[3]	AUF	no units	0.6 - 1		Mean AH: 38.3[5] ha HR: 48 ha
Exposure Duration[4]	ED[4]	no units	1		

Table B2. Ranges of Exposure Parameter Values for the Raccoon.[1]

1. Values from Table 3-68 of USEPA (2000) unless indicated. All mass units in ww.
2. AI: aquatic invertebrates. NR: non-river sources (no PCB exposure); maximum value from USEPA (2000).
3. AUF calculated from the spatial extent of the affected site habitat divided by the species specific home range: AUF = AH/HR. AH (affected habitat) determined from estimated surface area of affected area; see Report Section 4 and footnote 4; HR (home range) determined from USEPA (2000).
4. ED = sum of temporal correction factors in USEPA (2000).
5. Calculated from estimated habitat area of 4 miles of affected Dick's Creek length and an average of 0.037 mile width of river/floodplain/riparian area.
6. Range from EPA (1993).
7. PCB water exposure concentration set at 0 mg/L.
8. Alternative parameters were used for calculating TEC exposure because of benthic invertebrate data for dioxin-like PCB congeners were not available in the chemistry data sources used in the BERA (Section 3). fish: 3 ; AI: 0; FS: 0.

B3. Mink

Table B3. Ranges of Exposure Parameter Values for the Mink.[1]					
Parameter	**Symbol**	**Units**	**Range**		**Notes**
Body weight	BW	kg	0.83 - 1.02		Female - male
Total Daily Ingestion	IRwet	kg/d	0.132		
	IRdry	kg/d	0.059 - 0.069		
Water Consumption[6]	WI	L/d	0.084 - 0.101		Female - male
Diet Composition	PD	%	**Scenario 1** Stream: fish: 34 AI[2]: 16.5 Floodplain:[5] small mammal: 0 No PCBs: NR[2]: 49.5	**Scenario 2** Stream: fish: 34 AI[2]: 16.5 Floodplain:[5] small mammal: 25.3 No PCBs: NR[2]: 24.2	Alternative parameters used for calculating TEC exposure[7]
Incidental Sediment Ingestion	FS	%	1		Alternative parameter used for calculating TEC exposure[7]
Area Use Factor[3]	AUF	no units	1		AH: 6.44 km HR: 1.9 to 3.4 km
Exposure Duration[4]	ED[4]	no units	1		

1. Values from Table 3-69 of USEPA (2000) unless indicated. All mass units in ww.
2. AI: aquatic invertebrates. NR: non-river sources (no PCB exposure); maximum value from USEPA (2000).
3. AUF calculated from the spatial extent of the affected site habitat divided by the species specific home range: AUF = AH/HR. AH (affected habitat) determined from estimated length of affected stream (4 miles; see Report Section 4); HR (home range) determined from USEPA (2000).
4. ED = sum of temporal correction factors in USEPA (2000).
5. Range from EPA (1993).
6. PCB water exposure concentration set at 0 mg/L.
7. Alternative parameters were used for calculating TEC exposure because benthic invertebrate data for dioxin-like PCB congeners were not available in the chemistry data sources used in the BERA (Section 3). fish: 34; AI: 0; FS: 0.

B4. Robin

Table B1. Ranges of Exposure Parameter Values for the Robin.[1]

Parameter	Symbol	Units	Range	Notes
Body weight	BW	kg (ww)	0.0635 - 0.103	
Ingestion rate[2]	IRwet	kg/d (ww)	0.101 - 0.163	
	IRdry	kg/d (dw)	0.016 - 0.0.026	
Water Consumption[2]	WI	L/d	0.012	PCB water exposure concentration set at 0 mg/L.
Diet Composition[3]	PD	%	earthworm: 50.5 NC: 49.5	
Incidental Soil Ingestion	FS	%	10.4[5]	
Area Use Factor[4]	AUF	unitless	1	HR: 0.12 - 0.84 ha
Exposure Duration	ED	unitless	1	

1. Values from EPA (1993) unless otherwise noted. All mass units in ww.
2. Calculated assuming average body weight of 0.083 kg. Dry weight ingestion calculated assuming 84% moisture content of earthworms (Sample et al., 1999).
3. Earthworm is representative of contaminated foot items. Diet composition determined from annual average of reported values for central United States. NC: not contaminated (no PCB exposure).
4. AUF considered 1 because of small home range relative to area of affected floodplain.
5. Beyer et al. (1994) value for woodcock. Considered applicable to robin because of similar feeding habits.

B5. Kestrel

Table B5. Ranges of Exposure Parameter Values for the American Kestrel.[1]

Parameter	Symbol	Units	Range	Notes
Body weight[2]	BW	kg (ww)	0.085 - 0.142	
Ingestion rate[3]	IRwet	kg/d (ww)	0.31	
	IRdry	kg/d (dw)	NA	
Water Consumption	WI	L/d	0.01	PCB water exposure concentration set at 0 mg/L.
Diet Composition[4]	PD	%	small mammal: 41.4 NC: 58.6	
Incidental Soil Ingestion[5]	FS	%	0	
Area Use Factor[6]	AUF	unitless	0.05 - 0.1	HR: 21 - 215 ha
Exposure Duration	ED	unitless	1	

1. Values from EPA (1993) unless otherwise noted. All mass units in ww.
2. Source: Ohio Department of Natural Resources (www.dnr.state.oh.us/wildlife/resources/wildnotes/pub082.htm).
3. Ohio ww ingestion rate value. Dry weight ingestion rate not applicable (NA) because zero soil ingestion is assumed.
4. Small mammal represents contaminated food items; based on average of California data on mammal consumption. NC: not contaminated (no PCB exposure).
5. No information on incidental soil ingestion. Assumed to be zero based on feeding habits.
6. Area of affected habitat is uncertain. Assumed 5 to 10% of home range is contaminated (1.05 - 21.5 ha); this is based on 10 fold range in home range values and maximum contaminated habitat for raccoon of 39.5 ha (which included water surface area).

Appendix C

Derivation of Wildlife Screening Values for PAHs

Overview

This Appendix provides the derivation of total polycyclic aromatic hydrocarbon (tPAH) screening values for birds and mammals. These screening values were derived because appropriate tPAH dietary benchmarks for wildlife were not available in Sample et al. (1996) or other standard reference sources. The derivation was consistent with Barron and Holder (2003).

Table C1. Derivation of Wildlife Dietary Wildlife Screening Values for Total Polycyclic Aromatic Hydrocarbons (tPAH).[2]

Parameter	Bird	Mammal
Reference article	Mazet et al. (2001)	Patton and Dieter (1980)
Test species	mallard	mink
Dietary test material	PAH mixture (low MW)[1]	Alaska North Slope crude oil
Test duration	7 months	60 d prior to breeding to kit weaning
Life stage tested	subadults	lifecycle
Endpoints	growth, organ weight	P1 survival, reproduction F1 survival, reproduction
Test Concentrations	0, 400, 4,000 mg/kg diet (ww)	0, 500 mg/kg diet (ww)
Significant Effects	LOEC: 400 mg/kg (growth reduction, organ enlargement)	LOEC: 500 mg/kg (reduced reproductive success, kit survival, F1 reproductive success)
LOEC adjustment	20 (low MW PAH mixture; no reproductive endpoint)	20 (severe effects at test LOEC)
LOEC TRV:	20 mg/kg diet (ww)	25 mg/kg diet (ww)
NOEC TRV:	2 mg/kg diet (ww)	2.5 mg/kg diet (ww)

1. Test mixture contained only low molecular weight (MW) PAHs (2 and 3 rings).
2. See Barron and Holder (2003) for additional discussion.

Appendix D

June 2002 Site Visit Summary and Photographs

Overview

Dr. Mace Barron visited on-site and off-site areas (described in the observations below) of Dick's Creek and the AK Steel site on June 5, 2002, along with representatives of the U.S. Department of Justice, the State of Ohio, USEPA, and AK Steel. Dr. Barron made observations and took eight off-site photographs of Dick's Creek and warning signs (provided below). AK Steel did not allow photographs on site or at Monroe Ditch.

Ecological Risk Assessment Observations

Ecological observations included the following:

- Water was flowing in a drainage channel running east to west that entered Monroe Ditch near the southern site boundary. The channel appeared to be downgradient of the former contaminated ponds and may have been a source of historical PCB entry.

- Monroe Ditch appears to have heavy flows at times, as evidenced by the large upstream culverts at the railroad tracks and waste-high stream debris at the stream bank near the culverts.

- A mallard duck was in Monroe Ditch just upstream of the site property.

- Monroe Ditch appears to serve as aquatic habitat, as evidenced by multiple pools and riffles, an established riparian corridor on both stream banks, and small birds and dragonflies (species not identified) present in the riparian corridor. Several areas of the stream appeared to be deep enough to support small fish.

- OEPA commented that Monroe Ditch was classified as a water of Ohio and was considered to be aquatic habitat.

- The interceptor trench only captured groundwater flows on the east bank of Monroe Ditch. The interceptor trench, as was described by AK Steel, appeared not to intercept all potentially contaminated flows on the east side of Monroe Ditch.

- A seep was evident near the interceptor trench, and T. Barber (AK Steel contractor) indicated that PCBs had been detected at that location.

- A channel on the west side of the landfill (west of Monroe Ditch near western AK property line) contained water but was not flowing.

- Petroleum contamination in sediment was evident at the mouth of Monroe Ditch. Rainbow sheening and petroleum odor were produced when the sediment was disturbed, and a sheen flowed into Dick's Creek.

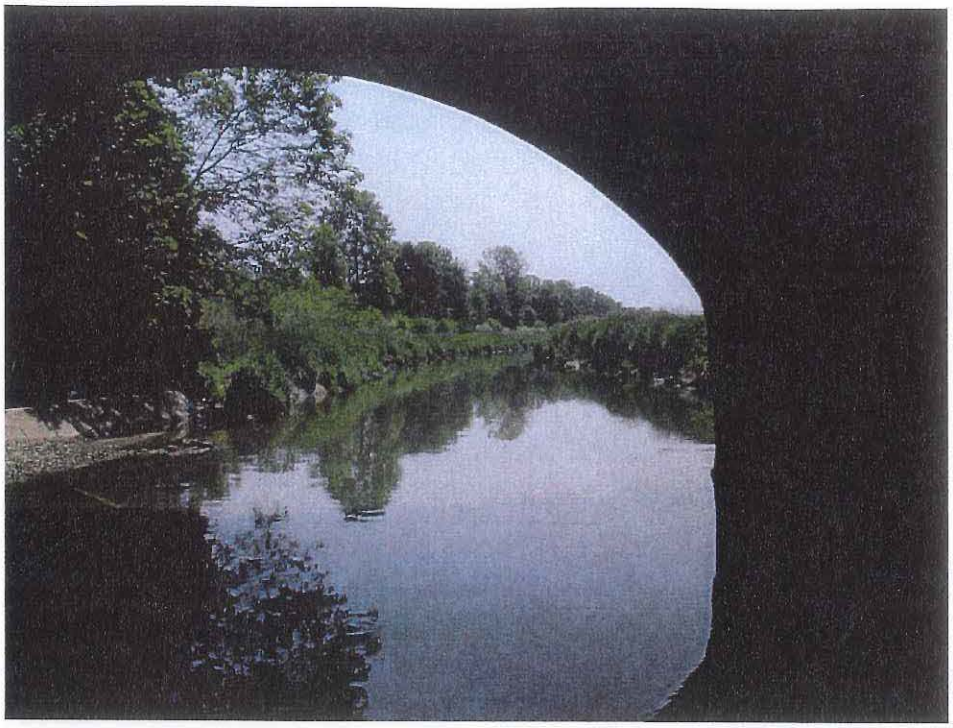
- A partially fallen warning sign (no bathing, fish, drinking) near Monroe Ditch was

- A partially fallen warning sign (no bathing, fish, drinking) near Monroe Ditch was photographed. Waist-high stream debris on the sign indicated that Dick's Creek was subject to high flows that submerge the floodplain.

- Dick's Creek was channelized near Monroe Ditch, and sediments had filled the former concrete channel. The floodplain consisted of sandy soils and abundant vegetation that would likely support amphibians and wildlife. Racoon and deer tracks were evident near the mouth of Monroe Ditch, and a hawk was observed in the area. Photographs were taken looking upstream and downstream on Dick's Creek near Monroe Ditch.

- Two additional sections of Dick's Creek were observed: near the Excello trailer park (~1.25 miles downstream of Monroe Ditch; channelized area) and Amanda Grammar School (~0.75 miles downstream of Monroe Ditch; natural channel with established riparian area). Both stream areas were photographed.

Dick's Creek looking downstream from rail road bridge and Monroe Ditch (Photos 1 and 2).



Dick's Creek looking upstream from rail road bridge (Photo 3; top) and floodplain vegetation and sign near Monroe Ditch (Photo 4; bottom).

Dick's Creek looking upstream near trailer park (Photo 5; top) and near Amanda school (Photo 6; bottom).

Dick's Creek near Amanda school showing stream channel (Photo 7) and sign in proximity to creek (Photo 8; bottom).

Appendix E

OEPA and USEPA Additional Data Collection Activities

Overview

This Appendix summarizes additional data collection activities in support of the ecological risk assessment performed during 2002 and 2003 by the OEPA and USEPA. Three data collection activities were performed:

- Collection of whole body fish samples from Dick's Creek in July 2002 by OEPA for the analysis of total PCBs (OEPA, 2002). Data are presented in Table F4-3 and were used in the assessment of PCB risks.

- Collection of sediment and floodplain samples from Dick's Creek in March 2003 by USEPA for the analysis of total PCBs, PCB congeners, and PCDDs/PCDFs (EPA, 2003b). Floodplain soil samples were also analyzed for inorganic and organic compounds, and these data were used in screening risks to terrestrial organisms.

- Collection of July 2002 fish fillet samples by OEPA for the analysis of total PCBs, PCB congeners, and PCDDs/PCDFs (EPA, 2003b). PCB data are summarized in Table G2-3 and were used in the quantitative assessment of PCB risks and to screen for risks of PCDDs/PCDFs.

Appendix F

Total PCB Data Used in the BERA

Overview

This Appendix provides exposure data for PCBs in Dick's Creek sediment (F1), aquatic plants (F2), benthic invertebrates (F3), fish (F4), and floodplain soil (F5), and Monroe Ditch sediment (F6). Surface water data for PCBs are summarized in Section 4.

F1. Sediment

Table F1-1. Total PCBs in Surface Sediment from Dick's Creek (mg/Kg dw) Collected during 2000 and 2001 (Arcadis, 2001b).[1]

Sample Location	PCBs (mg/kg)	River Mile[3]	PCBs (mg/kg 1% OC)	Collection Date
DCSD01B	0.65	0.12	0.16	February 2001
DCSD03	0.22	0.25	0.05	January 2001
DCSD04	0.06	0.53	0.03	January 2001
DC27s	7.32	0.85	3.53	September 2000
DCSD05	0.56	0.9	0.24	January 2001
E	0.26	1.0	0.05	September 2000
DC26	0.17	1.03	0.03	September 2000
DCSD06	2.28	1.1	1.33	January 2001
DCSD07	2.03	1.42	0.99	January 2001
D	3.36	1.5	0.80	September 2000
DCSD08	1.82	1.64	0.58	January 2001
DCSD09A	0.75	1.92	0.33	January 2001
DCSD10	0.34	2.0	0.08	January 2001
DCSD11	1.87	2.1	1.16	February 2001
DCSD12	0.28	2.3	0.06	February 2001
DC-16s	0.04	2.34	0.02	September 2000
DCSD13	0.13	2.45	0.03	January 2001
C	0.72	2.5	0.19	September 2000
DCSD14	0.06	2.53	0.01	January 2001

Table F1-1. Total PCBs in Surface Sediment from Dick's Creek (mg/Kg dw) Collected during 2000 and 2001 (Arcadis, 2001b).[1]				
Sample Location	PCBs (mg/kg)	River Mile[3]	PCBs (mg/kg 1% OC)	Collection Date
DCSD15	0.12	2.72	0.02	January 2001
B	0.07	2.76	0.02	September 2000
DCSD16	0.79	2.82	0.19	January 2001
DCSD17	1.1	3.05	0.36	January 2001
02SD01	2.8	3.08	0.68	January 2001
DC-09s	0.67	3.085	0.27	September 2000
DCSD18	0.04	3.26	0.01	January 2001
DCSD19	0.04	3.54	0.01	January 2001
DC-04s	0.03	3.64	0.01	September 2000
DCSD20	0.04	3.8	0.01	January 2001
DCSD21[2]	0.04	4.14	0.01	January 2001
DCSD22[2]	0.04	4.2	0.01	January 2001
A[2]	0.03	4.33	0.004	September 2000
DCSD23[2]	0.04	4.56	0.01	January 2001
DCSD24[2]	0.04	4.75	0.01	January 2001
DCSD25[2]	0.04	5	0.01	January 2001

1. Surface sediment data (0-6 inches) from Table 3 of Arcadis (2001b). Data are total PCBs normalized to 1% total OC. Mean value if multiple samples collected at same date and location.
2. Shaded cells are background data. Background levels considered to occur upstream of river mile 4 for the BERA.
3. Estimated from Arcadis (2001a) Figure 3-1.

Table F1-2. Total PCBs in Surface Sediment from Dick's Creek (mg/Kg dw) Collected during 2000 (OEPA, 2001a).[1]			
Sample ID	**PCBs (mg/kg)**	**River Mile**	**PCBs (mg/kg 1% OC)[4]**
34619[2]	ND (<0.037)	5.01	ND
34620[2]	ND (<0.033)	4.25	ND
34585	ND (<0.032)	3.9	ND
32295[3]	27.7	2.92[3]	6.93
34594	2.91	2.82	1.32
34592	48.2	2.6	25.4
34595	2.47	1.75	1.18
34591	3.39	0.93	1.26
34582	1.93	0.2	0.71

1. Mean value if multiple samples collected at the same location. ND: not detected.
2. Shaded cells are background data. Background levels considered to occur upstream of river mile 4 for the BERA. PCB contamination not apparent upstream of river mile 3.9.
3. Outfall 002 Ditch
4. PCB data normalized to 1% OC content for screening of risks to benthic invertebrates.

Table F1-3. Total PCBs in Surface Sediment from Dick's Creek (mg/Kg dw) Collected during 2003 (USEPA, 2003a).[1]			
Sample ID	**PCBs (mg/kg)**	**River Mile[3]**	**PCBs (mg/kg 1% OC)[4]**
S19 [2]	ND (<0.0196)	5.48	ND
S18 [2]	ND (<0.0221)	4.53	ND
S17	ND (<0.0227)	3.5	ND
S16	ND (<0.0225)	3.35	ND
S15	ND (<0.0244)	3.03	ND
S14[5]	3.91	2.92[5]	1.50
S13, D42	3.14	2.81	3.66
S12	15.0	2.76	18.8
S09	16.6	2.64	33.2
S31	2.22	2.58	3.17
S08	0.88	2.55	0.98
S07	19.9	2.45	22.1
S06	0.75	2.00	1.50
S05	3.30	1.87	5.50
S04	0.64	1.70	0.49
S03	2.14	1.63	1.02
S01	3.15	0.90	1.85

1. Mean value if multiple samples collected at the same location. ND: not detected using Aroclor-based PCB analysis.
2. Shaded cells are background data. Background levels considered to occur upstream of_river mile 4 for the BERA. PCB contamination not apparent upstream of_river mile 3.
3. River mile provided by USEPA.
4. PCB data normalized to 1% OC content for screening of risks to benthic invertebrates.
5. Outfall 002 ditch.

F2. Aquatic Plants

Table F2-1. Total PCBs in Aquatic Plants (mg/kg ww).[1,2]		
Location[3]	**PCBs (mg/kg ww) October 1999**	**PCBs (mg/kg ww) August 2000**
A[4]	ND (0.005)	ND (0.033)
B	ND (0.005)	0.284
C	0.010	0.207
E	ND (0.005)	0.057

1. Table B-5 of Arcadis (2001a). Plants are *Elodea spp.* (p. 18 of Arcadis, 2001a).
2. ND: not detected. Value in parentheses is one half of reported detection limit.
3. Approximate Dick's Creek river mile estimated from Figure 3-1 of Arcadis (2001a): location A (4.33), location B (2.76), location C (2.5), location D (1.5), location E (1).
4. Shaded cells are background data. Background levels considered to occur upstream of river mile 4 for the BERA.

F3. Benthic Invertebrates

Table F3-1. Total PCBs in benthic invertebrates from Dick's Creek (mg/kg ww).

Species	PCBs	Collection Location[3]	Collection Date	Data Source[1]
crayfish[2]	ND (<0.040[4])	Location A	August 2000	Arcadis (2001a)
crayfish	2.462	Location B	August 2000	Arcadis (2001a)
crayfish	0.302	Location C	August 2000	Arcadis (2001a)
crayfish	0.124	Location D	August 2000	Arcadis (2001a)
crayfish	1.086	Location E	August 2000	Arcadis (2001a)
Odonates[2]	ND (<0.0175[4])	Location A	October 1999	Arcadis (2001a)
Odonates	0.126	Location B	October 1999	Arcadis (2001a)
Odonates	0.123	Location C	October 1999	Arcadis (2001a)
Odonates	0.098	Location D	October 1999	Arcadis (2001a)
Odonates	0.161	Location E	October 1999	Arcadis (2001a)

1. Table B-8.
2. Shaded cells are background data. Considered to occur upstream of river mile 4 for the BERA.
3. Reported Dick's Creek station name. Approximate Dick's Creek river mile: Amanda (1.63), USGS (2.45), Beaver Dam (2.36), North Branch (5.2), location A (4.33), location B (2.76), location C (2.5), location D (1.5), location E (1). Locations A to E estimated from Figure 3-1 of Arcadis (2001a).
4. ND: Not detected at concentration in parentheses.

F4. Fish

Table F4-1. Total PCB Concentrations in Fish (mg/kg ww) from Arcadis (2001a).[1]							
Fish Category	Species	Length (cm)	PCBs (mg/kg ww)	Lipid Fraction	PCBs (mg/kg lipid)	Sample Location[5]	Collection Date
small fish species	spotfin shiner[2]	NR[3]	0.095[4]	0.033	28.8	Location A	August 2000
	spotfin shiner	NR[3]	2.001	0.025	80.0	Location B	August 2000
	spotfin shiner	NR[3]	2.517	0.036	69.9	Location C	August 2000
	spotfin shiner	NR[3]	4.228	0.040	106	Location D	August 2000
	spotfin shiner	4.0 - 7.0	2.617	0.014	187	Location E	August 2000
	spotfin shiner[2]	6.8 - 9.8	0.421	No data	NC[3]	Location A	October 1999
	spotfin shiner	NR[3]	0.656	No data	NA	Location B	October 1999
	spotfin shiner	6.5 - 9.2	1.08	No data	NA	Location C	October 1999
	spotfin shiner	6.0 - 10.7	1.91	No data	NA	Location D	October 1999
	spotfin shiner	NR[3]	4.419	0.013	340	Location E	October 1999
medium fish species	longear sunfish[2]	9.0 - 13.0	0.256	0.014	18.3	Location A	August 2000
	longear sunfish	9.5 - 11.8	2.093	0.0095	220	Location B	August 2000
	longear sunfish	10.0 - 12.7	1.625	0.0057	285	Location C	August 2000
	longear sunfish	11.0 - 15.0	8.415	0.035	240	Location D	August 2000

Table F4-1. Total PCB Concentrations in Fish (mg/kg ww) from Arcadis (2001a).[1]							
Fish Category	**Species**	**Length (cm)**	**PCBs (mg/kg ww)**	**Lipid Fraction**	**PCBs (mg/kg lipid)**	**Sample Location[5]**	**Collection Date**
	green sunfish	9.5 - 15.0	2.337	0.015	156	Location E	August 2000
	longear sunfish[2]	10.0 - 12.6	1.15	No data	NC[3]	Location A	October 1999
	longear sunfish	NR[3]	5.39	No data	NC[3]	Location B	October 1999
	longear sunfish	11.1 - 13.5	2.904	0.0046	631	Location C	October 1999
	longear sunfish	8.9 - 11.7	3.703	0.015	247	Location D	October 1999
	longear sunfish	9.8 - 10.6	5.82	No data	NC[3]	Location E	October 1999

1. Arcadis (2001a) Table B-11.
2. Shaded cells are background data. Background levels considered to occur upstream of river mile 4 for the BERA.
3. NR: length not reported; NC: could not be calculated because lipid data were not reported.
4. Reported as one half of detection limit.
5. Locations A to E estimated from Figure 3-1 of Arcadis (2001a). A: 4.33 mi; B: 2.76 mi: C: 2.5 mi; D: 1.5 mi; E: 1.0.

Table F4-2. Ohio EPA (OEPA, 2000b) total PCB Concentrations in Whole Fish (mg/kg ww) Collected in October 2000						
Fish Category	**Species**	**Length (cm)**	**PCBs (mg/kg ww)**	**Sample Location (river mile)**	**Lipid Fraction**	**Collection Date**
medium fish species	creek chub	12.7 - 13.2	3.612	1.7	0.0241	October 2000
	longear sunfish	10.5 - 11.9	5.955	1.7	0.0346	October 2000
	longear sunfish	8.8 - 12.5	2.971	2.6	0.0215	October 2000
	creek chub	15.6 - 18.2	3.439	2.8	0.0159	October 2000
	longear sunfish	8.3 - 10.6	1.812	2.8	0.0263	October 2000
large fish species	Yellow bullhead	17.9 - 20.7	3.832	1.7	0.0412	October 2000
	Carp	27.1	7.129	1.7	0.0506	October 2000
	White sucker	26.2 - 30.9	2.465	1.7	0.0127	October 2000
	Carp	31.0 - 37.2	7.584	2.6	0.028	October 2000
	White sucker	17.6 - 33.1	1.080	2.6	No data	October 2000
	Carp	26.3 - 28.8	1.827	2.8	0.0331	October 2000
	White sucker	26.2 - 30.3	0.569	2.8	0.00623	October 2000

Table F4-3. Ohio EPA (OEPA, 2002) total PCB Concentrations in Whole Fish (mg/kg ww and mg/g lipid) Collected in July 2002 ***Shaded cells are background data.***[1]

Fish Category	Species	Fish Length (cm)	PCBs (mg/kg ww)	Lipid Fraction	PCBs (mg/kg lipid)[3]	Sample Location (river mile)
medium fish species	Creek chub[1]	9.6-15.0	0.026	0.0572	0.45	5.5
	Green sunfish[1]	10.0-14.1	0.045	0.0321	1.40	5.5
large fish species	White sucker[1]	16.4-20.5	0.071	0.0785	0.90	5.5
medium fish species	Longear sunfish	12.7-13.4	6.17	0.0218	283	2.8
	Longear sunfish	10.2-12.3	9.32	0.0272	343	2.5
	Green sunfish	13.0-16.6	7.48	0.0285	262	2.5
	Longear sunfish	11.2-13.3	5.535	0.0249	222	1.7
	Green sunfish	12.0-15.1	4.489	0.0260	172	1.7
large fish species	golden redhorse	22.9-26.2	7.435	0.0663	112	2.8
	Yellow bullhead	19 (n=1)	0.695	0.00424	163	2.8
	golden redhorse	22.1-24.3	17.095	0.0497	343	2.5
	golden redhorse	22.0-22.8	7.433	0.0433	172	1.7

1. Shaded cells are background data. Background levels considered to occur upstream of river mile 4 for the BERA.
2. Calculated from: PCB [mg/g lipid] = PCB [mg/kg ww]/[lipid fraction]; lipid fraction is lipid percent reported in OEPA (2002) divided by 100. Lipid normalization is used in extrapolating TEC in congener fillets to TEC in fish eggs and whole body prey fish (Appendix G).

F5. Floodplain Soils

Table F5-1. Total PCBs in Surface Soils from the Dick's Creek Floodplain (mg/Kg dw) Collected in 2001 (Arcadis, 2002a) and 2003 (USEPA, 2003a)[1]

Sample ID	PCBs (mg/kg)	Location (River Mile)[3]	Source
DCFS-03[2]	ND[4]	Outfall 015-Outfall 003 (NR)	Arcadis (2002a)
DCFS-04	ND[4]	Outfall 003-Outfall 002 (NR)	Arcadis (2002a)
DCFS-05	0.17	Outfall 002-Monroe Ditch (NR)	Arcadis (2002a)
DCFS-06	0.05	Monroe Ditch-Yankee Road (NR)	Arcadis (2002a)
S22, D32	0.16	Near Amanda School (1.78)	USEPA (2003a)
S23	39.2	Near USGS Station (2.45)	USEPA (2003a)
S24	2.62	Upstream of Yankee Road (2.45)	USEPA (2003a)
S25	2.58	Upstream of Yankee Road (2.58)	USEPA (2003a)
S26	1.28	Near Monroe Ditch (2.72)	USEPA (2003a)
S27	3.05	Near Excello (1.0)	USEPA (2003a)
S29	1.26	Near Arts Parts (2.68)	USEPA (2003a)
S30	0.271	Near Simpson Paper (0.85)	USEPA (2003a)

1. Table 1 of Arcadis (2002a): sample depth of 0 to 2 feet. Only Dick's Creek data included. Data for all 12 samples were used in the estimation of floodplain risks to ecological receptors.
2. Shaded cells are background data. Defined as PCB concentrations in samples collected upstream of Dick's Creek river mile 4 for the BERA. PCB contamination not apparent upstream of Outfall 002.
3. Dick's Creek river mile or NR (not specified).
4. ND: not detected using Aroclor-bases analyses. Detection limit not reported in Arcadis (2002a). ND values defined as 0 mg/kg for the assessment of floodplain risks.

F6. Monroe Ditch

Table F6-1. Total PCBs in Surface Sediments from Monroe Ditch (mg/Kg dw) Collected in 1999 (USEPA, 1999b), 2001 (Arcadis, 2001d), 2000 (OEPA, 2000a), and 2003 (USEPA, 2003a)

Sample ID	PCBs (mg/kg)	Location	PCBs (mg/kg 1% OC)[2]	Collection Year	Source
S08[1]	ND (<0.063)	Near Todhunter Rd.	NR	1999	USEPA (1999b)
MDUPSD01[1]	ND (<0.043)	Between rail overpass and Todhunter Rd.	ND	2001	Arcadis (2001d)
MDSD05	0.33	Downstream of rail overpass	0.14	2001	Arcadis (2001d)
S06	16.6	Near treatment system	NR	1999	USEPA (1999b)
MDSD04	1.55	Near treatment system	1.18	2001	Arcadis (2001d)
S11, D33	0.88	Downstream of treatment system	0.71	2003	USEPA (2003a)
MDSD03	0.12	Upstream of Dick's Creek confluence	0.09	2001	Arcadis (2001d)
S04	16.8	Near confluence with Dick's Creek	NR	1999	USEPA (1999b)
MDSDO2	0.11	Upstream of Dick's Creek confluence	0.05	2001	Arcadis (2001d)
34593	1.8	Near confluence with Dick's Creek	0.72	2000	OEPA (2000a)
MDSD01	14.0	Near confluence with Dick's Creek	8.05	2001	Arcadis (2001d)
S10	1.35	Near confluence with Dick's Creek	2.25	2003	USEPA (2003a)

1. Shaded cells are background data. Upstream of AK Steel facility.
2. PCB data normalized to 1% content for assessing risks to benthic invertebrates. NR: OC not reported.

Appendix G

Dioxin-Like PCB Congener Data Used in the BERA

Overview

This Appendix provides exposure data for dioxin-like PCB congeners in fish (USEPA, 2003b). Congener-specific data were used in a probabilistic assessment of risks that incorporated the uncertainty and variability in exposure to dioxin-like congeners and is used as part of the weight of evidence evaluation; see Section 6.

Congener-specific data in fish were only collected in fillets of large species of fish (USEPA, 2003b), which are not directly applicable in the BERA. Wildlife benchmarks are available for whole fish (small and medium sized species preyed upon by wildlife) and developmental toxicity benchmarks are available for fish eggs. Fish fillet data were first converted to toxicity equivalence concentrations (TEC) of dioxin-like congeners, then to TECs in fish eggs (large fish species) and whole fish (small and medium size species consumed by wildlife) following stepwise procedures below:

1) Concentrations of dioxin-like congeners (ng/g ww tissue) in fish fillets were converted to lipid normalized concentrations (ng/g lipid weight) by dividing the ww concentration by the lipid fraction: [PCB ng/g lipid] = [PCB ng/g ww]/[lipid fraction]. Lipid normalization is used in extrapolating TEC in congener fillets to TEC in fish eggs and whole body prey fish.

2) The TEC in each fillet sample was calculated from the sum of the products of each lipid normalized congener concentration and the toxicity equivalency factor (TEF) for each congener (Table G1-1): [TEC ng/g lipid] = sum [PCB ng/g lipid]*[TEF]. Separate TECs were determined for fish, birds, and mammals because the World Health Organization (WHO) TEFs differ for each category of vertebrates (Table G1-1).

TEC in Eggs of Large Fish

3) TECs (ng/g lipid) in fillets were calculated as described in step 2 above, using the fish-specific TEFs (Table G1-1).

4) The egg TEC (ng/g ww) for each fish sample with fillet data (Table G2-1) was calculated from the fillet TEC (ng/g lipid) divided by the lipid fraction of fish eggs (g lipid/g ww) reported by Elonen et al. (1998): [TEC ng/g ww] = [TEC ng/g lipid]*[g lipid/g ww] using egg data for the most similar species (Table G2-2).

Whole Body TEC in Small and Medium Fish

3) TECs (ng/g lipid) in fillets were calculated as described in step 2 above, using the bird and mammal-specific TEFs (Table G1-1) to allow estimation of wildlife exposures to fish containing dioxin-like congeners (Table G-2).

4) A whole fish to fish fillet ratio (WFR) was calculated to allow extrapolation of TEC prey concentrations only analyzed in large fish fillets to whole body concentrations in prey fish. The WFR was determined for total PCBs using whole body small and medium size fish collected

during the same period and same locations as the large fish fillets analyzed for PCB congeners and total PCBs: [WFR] = [mg total PCBs/kg whole body lipid]/[mg total PCBs/kg fillet lipids]. Table G2-4 summarizes the data used to calculate the WFR which ranged from 0.182 to 2.34.

5) Small and medium fish whole body TECs (ng/g ww) was calculated from the lipid fraction (g lipid/g ww), the fish fillet TEC (ng/g lipid) for birds and mammals (Table G2-1), and the WFR: [TEC ng/g ww] = [lipid fraction g lipid/g ww]*[WFR]*[TEC ng/g lipid]. The TEC was computed for each fish listed in Tables F4-1, F4-2, F4-3 using the fish specific lipid fraction, and a uniform distributions of TEC and WFR (Table G2-5).

G1. Toxicity Equivalency Factors

Table G1-1. Planar PCBs and World Health Organization (Van den Berg et al., 1998) Toxicity Equivalency Factors (TEFs)

Congener	Chlorines[1]	Fish TEF	Bird TEF	Mammal TEF
77	4	0.0001	0.05	0.0001
81	4	0.0005	0.1	0.0001
105	5	<0.000005	0.0001	0.0001
114	5	<0.000005	0.0001	0.0005
118	5	<0.000005	0.00001	0.0001
123	5	<0.000005	0.00001	0.0001
126	5	0.005	0.1	0.1
156	6	<0.000005	0.0001	0.0005
157	6	<0.000005	0.0001	0.0005
167	6	<0.000005	0.00001	0.00001
169	6	0.00005	0.001	0.01
189	7	<0.000005	0.00001	0.0001

1. Number of chlorine atoms in each congener.

G2. Toxicity Equivalence Concentrations in Fish

Table G2-1. Toxicity Equivalence Concentrations (TECs; ng/g lipid) Calculated from Concentrations of Dioxin-Like PCB Congeners in Fish Fillets (USEPA, 2003b)[1,2]

Fish Sample	River Mile	Fish TEC	Bird TEC[4]	Mammal TEC[4]
common carp	2.8	0.168	25.9	4.14
smallmouth bass	2.8	NC[3]	NC[3]	NC[3]
channel catfish	2.8	0.161	12.2	4.66
channel catfish	2.5	0.071	7.63	1.71
channel catfish	2.5	0.027	3.13	0.712
common carp	2.5	0.235	18.9	8.02
smallmouth bass	1.7	NC[3]	NC[3]	NC[3]
flathead catfish	1.7	0.354	28.1	11.0
channel catfish	1.7	0.327	15.3	12.2
common carp	1.7	0.135	17.0	3.61

1. Data are reported per g lipid and were normalized by the percent lipid reported by USEPA (2003b). Lipid normalization is used in extrapolating TEC in congener fillets to TEC in fish eggs and whole body prey fish.
2. TECs calculated using World Health Organization toxicity equivalency factors (TEF) for fish, birds, and mammals (see Table G1-1) and data from USEPA (2003b): TEC = sum (TEF_x*[PCB_x]) where TEF_x and [PCB_x] are the TEF and the PCB concentration of a single congener. TEC for fish excluded PCBs 105, 114, 118, 123, 156, 157, 167, and 189 because the TEF was less than 0.000005.
3. NC: not calculated because lipid data reported as 'ND' in laboratory report (USEPA, 2003b).
4. PCB 156 and PCB 157 could not be separately distinguished in the USEPA (2003a,b) chemistry analyses and the concentration results were presented as a total of PCBs 156 and 157. The total concentrations of PCBs 156 and 157 were used in computing the TEC (the results were not double counted). The TEFs for PCB 156 and PCB 157 are identical, thus this procedure did not increase the uncertainty in the TEC contribution of these congeners.

Table G2-2. Estimated TECs (ng/g lipid) in Fish Eggs			
Fish Sample	**Fillet TEC[1] (ng/g lipid)**	**Egg Lipid Fraction[2] (g lipid/g ww)**	**Egg TEC[3] (ng/g ww)**
common carp	0.168	0.025	0.0042
smallmouth bass	NC[4]	NC[4]	NC[4]
channel catfish	0.161	0.048	0.0077
channel catfish	0.071	0.048	0.0034
channel catfish	0.027	0.048	0.0013
common carp	0.235	0.025	0.0059
smallmouth bass	NC[4]	NC[4]	NC[4]
flathead catfish	0.354	0.048	0.0170
channel catfish	0.327	0.048	0.0157
common carp	0.135	0.025	0.0034

1. TECs calculated using World Health Organization toxicity equivalency factors (TEF) for fish (see Table G1-1): TEC = sum (TEF_x*[PCB_x]) where TEF_x and [PCB_x] are the TEF and the PCB concentration of a single congener. TEC for fish excluded PCBs 105, 114, 118, 123, 156, 157, 167, and 189 because the TEF was less than 0.000005.
2. Egg data from Table 2 of Elonen et al. (1998). White sucker value used as surrogate for carp.
3. Calculated from product of fillet TEC and egg lipid fraction. Lipid normalization is used in extrapolating TEC in congener fillets to TEC in fish eggs.
4. NC: not calculated because lipid data reported as 'ND' in laboratory report (USEPA, 2003b).
5. Equivalent to lipid normalized egg TEC (ng/g lipid); see Appendix G and Section 6.33.

Table G2-3. Total PCBs (mg/kg ww and mg/kg lipid weight) in large fish fillets collected in 2003 (USEPA, 2003b). *Data used in estimating TECs in fish eggs and prey fish.*						
Fish Sample	**Sum of Aroclors**		**Sum of Congeners**		**Lipid Fraction**	**Sample Location (river mile)**
	PCBs (mg/kg ww)	**PCBs (mg/kg lipid)[1]**	**PCBs (mg/kg ww)**	**PCBs (mg/kg lipid)[1]**		
common carp	4.85	147	18.5	561	0.033	2.8
smallmouth bass	1.40	NC[2]	4.21	NC[2]	NC[2]	2.8
channel catfish	0.77	76.5	3.22	322	0.010	2.8
channel catfish	1.07	53.5	3.79	190	0.020	2.5
channel catfish	1.13	45.2	2.43	97.2	0.025	2.5
common carp	4.22	234	11.1	617	0.018	2.5
smallmouth bass	0.83	NC[2]	4.16	NC[2]	NC[2]	1.7
flathead catfish	2.75	162	10.1	594	0.017	1.7
channel catfish	4.42	340	11.1	854	0.013	1.7
common carp	4.80	160	12.9	430	0.030	1.7

1. Calculated from: PCB [mg/g lipid] = PCB [mg/kg ww]/[lipid fraction]; lipid fraction is the percent lipid reported in USEPA (2003b) divided by 100. Lipid normalization is used in extrapolating TEC in congener fillets to TEC in fish eggs and whole body prey fish.
2. NC: not calculated because lipid data reported as 'ND' in laboratory report (USEPA, 2003b).

Table G2-4. Total PCBs (mg/kg lipid weight) in whole fish and large fish fillets. ***Data used in estimating TECs in fish eggs and prey fish.***					
River Mile	**Whole body PCBs in small-medium fish (mg/kg lipid)[1]**	**PCBs in large fish fillets (mg/kg lipid)[2]**		**Ratio of Small-Medium Whole Body Fish PCBs to Large Fish Fillet PCBs[3]**	
		Aroclor-based	**Congener-based**	**Aroclor-based**	**Congener-based**
2.8	283	112	442	2.53	0.640
2.5	303	111	301	2.73	1.01
1.7	197	221	626	0.891	0.315

1. Mean total PCB data for each river mile from OEPA (2002); see Table F4-3.
2. Mean total PCB data for each river mile from USEPA (2003b). Calculated from sum of Aroclor data or sum of all detected congeners; see Table G2-3. Lipid normalization is used in extrapolating TEC in congener fillets to TEC in fish eggs and whole body prey fish.
3. WFR: Ratio of small-medium fish PCBs (mg/kg lipid) and large fish fillet PCBs (mg/kg lipid) calculated from either total Aroclor or total congener data.

Table G2-5. Dioxin-like PCB Congener Exposure Data and Probability Distribution Functions Used in Risk Calculations[1]			
Parameter	**Units**	**Min-Max**	**Distribution**
TEC Bird	ng/g lipid	3.13 - 28.1	uniform
	ng/kg ww	26.0 - 727	uniform
TEC mammal	ng/g lipid	0.712 - 12.2	uniform
	ng/kg ww	5.39 - 1636	uniform
WFR[2]	unitless	0.315 - 2.73	uniform
lipid fraction	g lipid/g ww	fish-specific[3]	fish-specific[3]

1. Min-Max: minimum-maximum values; Distribution: probability distribution used in assessing wildlife risks.
2. WFR: whole body to fillet ratio (g lipid medium whole fish:g lipid large fish fillet). Lipid normalization is used in extrapolating TEC in congener fillets to TEC in whole body prey fish.
3. Data in Tables F4-1, F4-2 and F4-3.

Booz | Allen | Hamilton

Booz Allen & Hamilton Inc.
Second Floor
22 Batterymarch Street
Boston, MA 02109

Tel 1-617-428-4400
Fax 1-617-428-4410

www.boozallen.com

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Mr. Bernie Orenstein
Regional Project Officer
U.S. Environmental Protection Agency
77 West Jackson Blvd.
Chicago, IL 60604

Subject: EPA Contract No. 68-W-02-018, Corrective Action Work Assignment R05802, Technical Direction No. 1 AK Steel, Middletown, Ohio. Task 02. Technical Document Review and Preparation: Baseline Ecological Risk Assessment

Dear Mr. Orenstein:

In response to Work Assignment R05802, Technical Direction Memorandum (TDM) No. 1, under EPA Contract No. 68-W-02-018, please find attached the Baseline Ecological Risk Assessment (BERA). EPA contracted Booz Allen Hamilton to update the information in two Ecological Risk Assessments which were performed by AqualQual and Arcadis in 2001. Neither of these ERAs considered all of the available recent data and information collected by the AK Steel, the Ohio EPA and USEPA contractors. In addition, the results of these two ERAs were contradictory and highly uncertain.

The attached Baseline Ecological Risk Assessment is a definitive assessment of the ecological risks of AK Steel Site contaminants in Dick's Creek, as prepared by Dr. Mace Barron of ASE, Inc., which is a wholly owned subsidiary of Booz Allen Hamilton.

If you have any questions regarding this deliverable, please contact me at (254) 793-3419.

Sincerely,

Kristin McKinney

BOOZ ALLEN HAMILTON

for Phebe Davol
Work Assignment Manager

cc: Allen Wojtas, Work Assignment Manager
Gary Cygan, EPA Technical Lead
Mike Mikulka, Alternate Technical Lead
BAH EPMT QA/QC Coordinator

Baseline Ecological Risk Assessment for Dick's Creek

AK Steel
Middletown, Ohio

Submitted to:

Mr. Bernie Orenstein
Regional Project Officer
U.S. Environmental Protection Agency
Region 5
77 West Jackson Blvd.
Chicago, IL 60604

Prepared by:

Dr. Mace G. Barron, Ph.D.
ASE, Inc.

Under Contract for:

Booz Allen Hamilton

EPA Work Assignment No.:	R05802
Contract No.:	68-W-02-018
Booz Allen Hamilton WAM:	Phebe Davol
Telephone No.:	254/793-3419
EPA WAM:	Alan Wojtas
Telephone No.:	312/886-6194
EPA Technical Lead:	Gary Cygan
Telephone No.:	312/886-5902

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Acronym List

ADD	average daily dose
AH	affected habitat
AUF	area use factor
AWQC	ambient water quality criteria
BAF	bioaccumulation factor
BERA	baseline ecological risk assessment
CBR	critical body residue
COC	contaminant of concern
CSM	conceptual site model
dw	dry weight
ED	exposure duration
EPC	exposure point concentration
ERA	ecological risk assessment
HQ	hazard quotient
HR	home range
LOAEL	lowest observed adverse effect level
NOAEL	no observed adverse effect level
OC	organic carbon
OEPA	Ohio EPA
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
SV	screening value
tPAH	total polycyclic aromatic hydrocarbons
TRV	toxicity reference value
WSU	Wright State University
ww	wet weight

Executive Summary

This baseline ecological risk assessment (BERA) report assesses the risks from contaminants at the AK Steel Corporation (AK Steel) site in Middletown, Ohio to ecological receptors using and inhabiting Dick's Creek. The BERA has been prepared according to current USEPA guidance, including problem formulation, analysis of exposure and effects, and risk characterization (USEPA, 1997, 1998a, 2001a, 2001b).

Problem Formulation

Dick's Creek is a small stream in southwest Ohio that has received polychlorinated biphenyls (PCBs) and other contaminant releases from the AK Steel site. Dick's Creek generally flows east to west to its confluence with the Great Miami River and is in proximity to the AK Steel site from approximately river miles 2.5 to 5.5.

A hazard quotient (HQ) approach was used to identify contaminants of concern (COCs) using a systematic and moderately conservative screening process of comparing maximum detected contaminant concentrations and lowest observed adverse effect level (LOAEL) screening values. Exposure point concentrations were only calculated for detected contaminants using 1999 or more recent data, and non-detected analytes were excluded from consideration. Wildlife risks were determined using measured prey concentrations; only PCBs in terrestrial prey were estimated because no data were available.

PCBs were identified as the only COC in Dick's Creek for the following receptors and exposure pathways: (1) benthic invertebrate contact with sediment, (2) fish contact with surface water and accumulation of toxic body residues, and (3) piscivorous wildlife ingestion of surface water, benthic invertebrates, fish, and sediment (incidental). The mink, raccoon, and belted kingfisher were selected as piscivorous wildlife receptors because they are highly exposed (consume contaminated media and biota; have small home ranges), are sensitive to PCBs (particularly mink), and peer reviewed exposure parameters and toxicity reference values (TRVs) were available (USEPA, 2000). Other PCB exposure pathways and ecological receptors were either screened out with low confidence or there were not adequate data to allow a quantitative assessment of risks; these were qualitatively evaluated in the uncertainty analysis.

Analysis of PCB Exposure and Effects

Only 1999 or more recent data for surface water, sediment, groundwater seeps, flood plain soils, and biota were used from three sources: AK Steel/Arcadis, Wright State University/AquaQual, and the Ohio EPA. The lone exception was the use of data for two samples of large fish collected in 1998 by Arcadis (2001a). Only surface sediment data were considered in this BERA, and PCB concentrations were normalized to 1% organic carbon for the assessment of risks to benthic invertebrates.

Multiple AK Steel sources of PCBs exist along the site boundary, including contaminated groundwater seeps, Outfall 002 sediments, and Monroe Ditch. The available data consistently show that PCBs substantially increase in surface water, sediment, aquatic plants, benthic invertebrates, and fish below these source areas. PCBs are low or not detectable upstream of these source areas. PCB contamination has been detected for over three miles of Dick's Creek to nearly its confluence with the Great Miami River, and the available recent data (1999+) do not show any apparent declines in PCB concentrations.

TRVs were primarily obtained from USEPA (2000) because they have been rigorously evaluated and are applicable to assessing risks in Dick's Creek. Risks were assessed using a protection standard of an approximately 20% effect [e.g., risks were estimated using LOAEL TRVs and all applicable exposure data were incorporated] because of the absence of identified special status species and critical habitats.

Risk Characterization

A probabilistic assessment of PCB risks was used to estimate risks to benthic invertebrates, fish, and piscivorous wildlife because this approach incorporated the variability and uncertainty in exposure and toxicity, and provided directly interpretable risk descriptions for risk managers.

The available lines of evidence show that benthic invertebrates are at substantial risk from PCBs in Dick's Creek sediment downstream of AK Steel PCB sources. This conclusion is considered to be of high confidence because the spatial extent of PCBs has been well characterized, and risks were determined using TRVs indicative of population level effects. HQs ranged from 0.001 to 73.5, and the probability of exceeding median effect concentrations was 43%. Additionally, a qualitative evaluation of the results of recent ecological surveys and in situ toxicity tests also indicated adverse effects of contaminated sediments.

The available lines of evidence show that fish are at substantial risk from PCBs in Dick's Creek downstream of AK Steel PCB sources. This conclusion is considered to be of high confidence because the spatial extent of PCB bioaccumulation has been well characterized in fish, and risks were determined using TRVs indicative of adverse effects on a variety of fish species. HQs ranged from 0.02 to 10.9, and the probability of exceeding toxic levels of critical body residues of PCBs was 23.7%. The limited low detection data for PCBs in surface water indicated that chronic Ambient Water Quality Criteria (AWQC) was exceeded downstream of the AK Steel site.

Probabilistic risk estimates indicate that mink are at risk from ingestion of PCBs, with HQs ranging from 0.09 to 14.4, and a probability of exceeding ingestion TRVs of 43.5%. The conclusion of substantial risks to mink is considered to be of high confidence because of the high probability of exceeding TRVs based on population level effects (i.e., TRVs derived from LOAELs rather than no effect values).

Kingfishers and raccoons were not at risk from ingestion of PCBs, with probabilities of exceeding ingestion TRVs of less than 1%. The conclusions regarding raccoon and kingfishers have only moderate confidence because PCB exposure and risks maybe underestimated. PCB exposures derived from the Dick's Creek flood plain were not incorporated because of inadequate data, and wildlife may selectively feed in the natural stream sections that contain the most contaminated benthic invertebrate and fish prey species.

Background risks appear to be minimal in Dick's Creek, as evidenced by non-detections or very low contamination measured in surface water, sediment, aquatic plants, benthic invertebrates, and fish upstream of AK Steel PCB source areas.

Uncertainty Analysis

Several categories of ecological receptors were not quantitatively evaluated in this BERA, either because they were screened out with low confidence or there were not adequate data to allow a quantitative assessment of risks. Exclusion of these pathways and receptors represent a substantial uncertainty in the BERA, and indicate the potential to underestimate ecological risks for aquatic and terrestrial plants, amphibians and reptiles, soil invertebrates, terrestrial small mammals and birds, wildlife primarily feeding on aquatic plants (e.g., muskrats), and top predators such as hawks.

There were insufficient data to quantitatively assess the risks of PCBs in the soils of the Dick's Creek flood plain, or the potential future risks from resuspension and transport of PCBs in the Dick's Creek system. The limited available data indicate that high levels of PCBs are present in the subsurface in proximity to Monroe Ditch. Also, subsurface sediments contain higher concentrations of PCBs (Arcadis, 2001a), although only surface sediment data were used in the BERA. Observations from a June 5, 2002 site visit indicated that Dick's Creek is subject to high flows and substantial sediment movement as indicated by the width of the flood plain and the vertical extent of debris on flood plain vegetation. This suggests the potential for resuspension of the PCBs that are buried in Dick's Creek sediment, and the potential for transport of PCBs between Dick's Creek sediment and its flood plain.

PCB risks in Monroe Ditch were not quantitatively assessed because of insufficient available information, which was limited to seep monitoring data, and sediment and surface water concentrations at a location upstream of the site and near the confluence with Dick's Creek. High levels of PCBs detected in sediment at the mouth of Monroe Ditch suggest the potential for risks at upstream locations within the AK Steel site. Habitat for both aquatic organisms and wildlife were evident during the June 2002 site visit (Appendix D), thus complete exposure pathways and receptors are likely present.

An additional source of uncertainty is the potential for risks from the complex mixtures of contaminants in Dick's Creek (e.g., additive toxicity) and any unmeasured contaminants that were not analytes.

1. Introduction

1.1 Overview

Dick's Creek is a small stream in southwest Ohio that has received PCBs and other contaminant releases from the AK Steel Corporation (AK Steel) site in Middletown, Ohio, as described in Section 2 of this ecological risk assessment (ERA). Two recent ERAs have been previously reported for the Dick's Creek site:

- AqualQual. 2001. *Ecological Risk Assessment of Dick's Creek, Middletown, Ohio.* AquaQual Services, Inc. Prepared for Tetra Tech. April 30, 2001.

- Arcadis. 2001a. *Ecological Risk Assessment for Dick's Creek. Arcadis G&M, Inc.* Prepared for AK Steel Corp. June 1, 2001.

Neither ERA considered all of the available recent data and information collected by AK Steel contractors [i.e., Arcadis G&M (Arcadis)], the Ohio Environmental Protection Agency (OEPA), and USEPA contractors [Wright State University/AqualQual (WSU/AqualQual)]. Also, the results of these two ERAs were contradictory and highly uncertain. Because of these concerns, USEPA contracted Booz Allen Hamilton to perform and report a definitive assessment of ecological risks of AK Steel site contaminants in Dick's Creek. This ERA was performed by Dr. Mace Barron of ASE, Inc., which is a wholly owned subsidiary of Booz Allen Hamilton.

1.2 Guidance Used

Current USEPA guidance was used in preparing this ERA, including:

1. USEPA. 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments.* EPA 540-R-97-006. US Environmental Protection Agency, Edison, NJ.

2. USEPA. 1998a. *Guidelines for Ecological Risk Assessment.* EPA/630/R-95/002F. US Environmental Protection Agency, Washington, DC.

3. USEPA. 1999a. *Risk Assessment Guidance for Superfund: Volume 3 - (Part A, Process for Conducting Probabilistic Risk Assessment).* Draft. December 1999, Revision No. 5. www.epa.gov/superfund/progress/risk/rags3adt/index.htm

4. USEPA. 2001a. *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments.* ECO Update. EPA 540/F-01/014. US Environmental Protection Agency, Office of Solid Waste and Emergency Response. June 2001.

5. USEPA. 2001b. *Ecological Risk Assessment at Superfund and RCRA Corrective Action Sites*. ECO UPDATE. Interim Bulletin Number 13. US Environmental Protection Agency, Office of Solid Waste and Emergency Response. February.

1.3 Report Purpose and Organization

This report quantitatively and qualitatively evaluates the risks of AK Steel site contaminants on ecological receptors using and inhabiting Dick's Creek. The purpose of this report is to provide a defensible and comprehensive assessment of ecological risks to complete the RCRA administrative record. This report is organized according to the components of an ERA (e.g., USEPA, 1997, 1998) including problem formulation (Section 2), data used (Section 3), exposure analysis (Section 4), effects analysis (Section 5), and characterization of risks and uncertainties (Section 6). Section 7 provides the summary and conclusions, and Section 8 lists the information cited. The Appendices of the report provide a presentation of the (A) determination of contaminants of concern (COCs), (B) wildlife exposure parameters, (C) derivation of wildlife screening values for polycyclic aromatic hydrocarbons (PAHs), (D) June 2002 site visit and photographs, and (E) exposure data for ecological receptors.

2. Problem Formulation

2.1 Overview

The Problem Formulation describes the environmental setting (Section 2.2), identifies the potential contaminant sources and transport pathways (Section 2.3), identifies the COCs through a process of screening potential site contaminants (Section 2.4), describes ecological exposure and effects of the COCs (Section 2.5), selects the assessment and measurement endpoints and presents the conceptual site model (CSM) (Section 2.6), and describes the rationale for a baseline ERA (BERA) for polychlorinated biphenyls (PCBs) at the scientific/management decision point (Section 2.7).

2.2 Environmental Setting

2.2.1 Location and Description

Dick's Creek and the AK Steel site are located near Middletown, in southwest Ohio (Figure 2.1). Figure 2.2 presents an aerial photograph, and Figure 2.3 is a larger scale map showing Dick's Creek, Monroe Ditch, the North Branch of Dick's Creek and the AK Steel site. For the purposes of this ERA, the AK Steel site is defined as facility areas located on both the north and south side of Dick's Creek, including those associated with "OMS" operations. Dick's Creek generally flows east to west to its confluence with the Great Miami River, and is in proximity to the AK Steel site from approximately river mile 2.5 to 5.5 (Arcadis, 2001a). Production of steel, pig iron, coke, slag processing, and steel finishing and coating occur at the AK Steel site (AquaQual, 2001).

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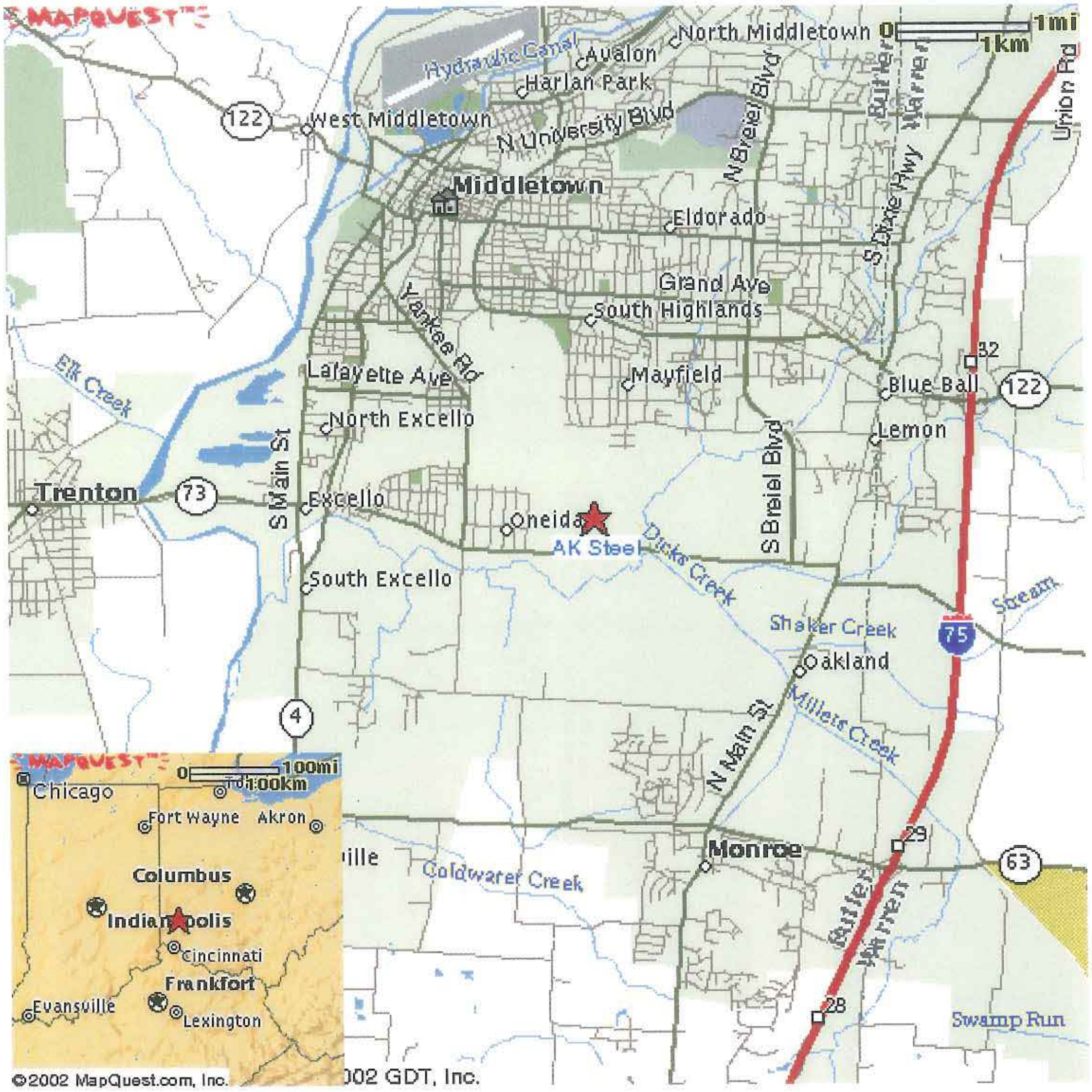

Figure 2-1. Map of Middletown, Ohio, showing location of AK Steel site (red star), and Dick's Creek. Inset map shows regional location.

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Figure 2-2. Aerial photograph of Middletown, Ohio, and Dick's Creek (center).

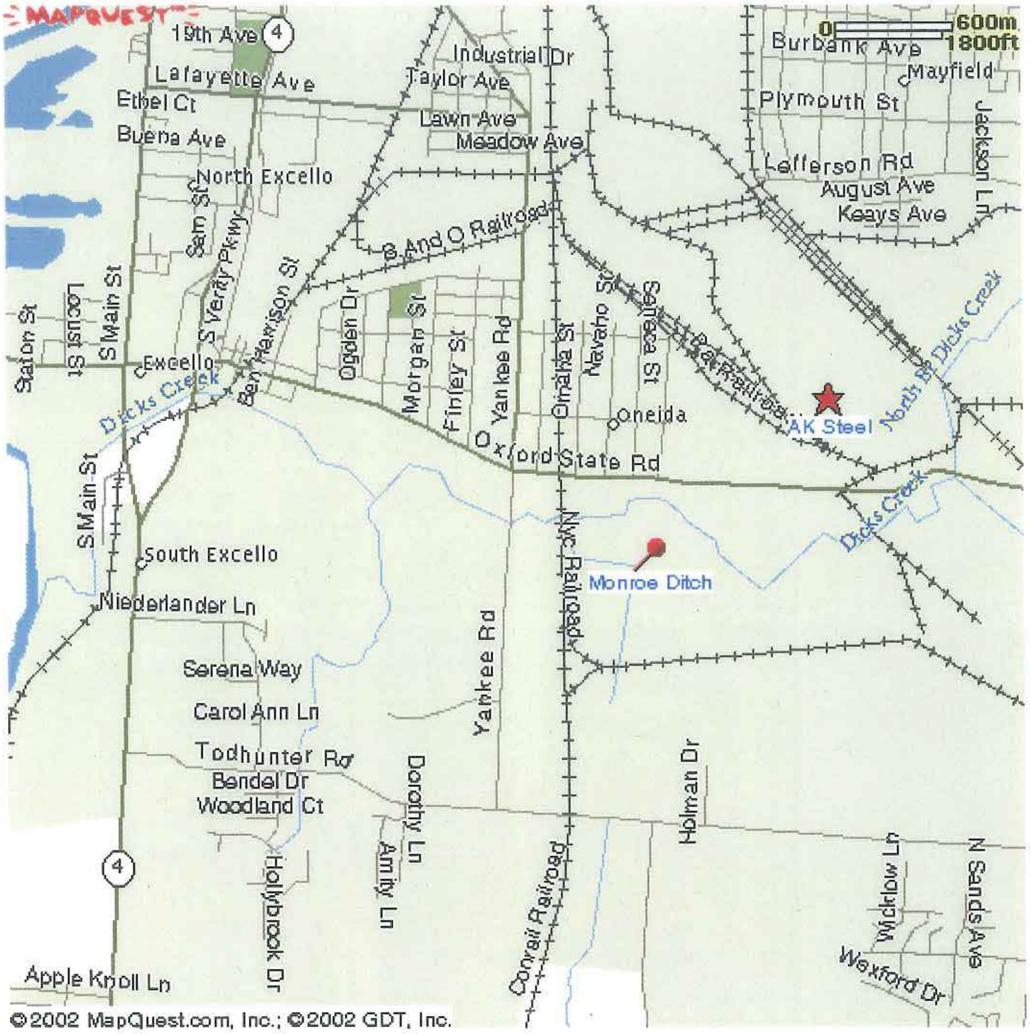

Figure 2-3. Larger scale map of Middletown, Ohio, showing Dick's Creek, Monroe Ditch (pin), and AK Steel site (red).

2.2.2 Habitat, Aquatic Organisms and Wildlife

General habitat descriptions and wildlife observations are provided in the previous AK Steel (Arcadis, 2001a) and USEPA (AquaQual, 2001) contracted ERAs, including:

- The area surrounding Dick's Creek includes: 3% open water, 2% non-forest wetland, 14% woodlands, 0.2% shrub land, 51% agriculture/open land, 29% urban land, and 1% barren land (Arcadis, 2001a).

- Dick's Creek is classified as a lower perennial, riverine, unconsolidated bottom, permanently flooded habitat, with water depths ranging from 0.5 to 4 feet (Arcadis, 2001a).

- Dick's Creek has a natural stream channel from approximately 100 meters west of Yankee Road Bridge to 200 meters east of the Main Street Bridge, and from approximately 150 meters west of Main Street Bridge to the confluence with Great Miami River (Arcadis, 2001a). Within non-channelized portions of Dick's Creek there is woody riparian habitat including large deciduous trees, and herbaceous vegetation, small trees and shrubs comprising the understory (Arcadis, 2001a).

- Portions of Dick's Creek were channelized in the 1960s, with the majority of the channelized portion in proximity to the AK Steel site (Arcadis, 2001a). Within the channelized portion, Dick's Creek is buffered by approximately 50 to 75 feet of dense herbaceous vegetation. Pioneer and early successional plant species dominate with a narrow rows of trees present and large trees limited to tops of stream banks (Arcadis, 2001a).

- Large grained sediments (e.g., sand) dominate in Dick's Creek and the sediment bottom was observed to be unstable (AquaQual, 2001). A fine layer of small grain sediment (e.g., clay, silt, organic matter) settles on most sediment surfaces (AquaQual, 2001). High flows are frequent in Dick's Creek following rain events, and high turbidity occurs during high flows (AquaQual, 2001).

- Arcadis (2001a) noted the following: (1) muskrat dens had been observed at Dick's Creek, particularly along the channelized portion of the creek; (2) raccoon tracks were observed in the channelized areas of Dick's Creek; (3) shoreline vegetated cover along non-channelized areas may support mink; (4) belted kingfisher were observed at Dick's Creek, particularly in the channelized portion; (5) great blue herons have been observed in proximity to Dick's Creek; (6) waterfowl, wading birds, and songbirds were observed in the area; and (7) snakes and frogs were evident.

- Arcadis (2001a) reported that 107 invertebrate taxa (e.g., midges, dragonflies and damselflies, beetles, caddisflies, mayflies) and 43 fish species (e.g., minnows, shiners, dace, sunfish, darters, carp, suckers, bass) have been observed in Dick's Creek. A 2000 ecological survey (Attachment D of Arcadis, 2001a) indicated that Dick's Creek, in proximity to and downstream of AK Steel had very poor to good habitat, (2) that two of these sample locations did not met biological criteria scores for macroinvertebrates, and (3) all locations met fish criteria.

- AquaQual (2001) concluded there was a good riparian zone with adequate habitat allowing for a high diversity of birds and small mammals to exist. AqualQual (2001) reported observations of plants, invertebrates, fish, amphibians, turtles, migratory and resident birds (e.g., robin, killdeer, geese, sparrows, mallard, kingfisher, heron), and mammals (e.g., deer, opossum, raccoon).

- AquaQual (2001) considered the Dick's Creek stream habitat to be of adequate quality, but survey results indicated poor quality benthic and fish communities. For example, few species of macroinvertebrates were present, pollution tolerant species dominated, with evidence of high bivalve mortality (AquaQual, 2001).

Previous investigations did not identify any special status species or critical habitats in proximity to Dick's Creek (AquaQual, 2001; Arcadis, 2001a).

2.2.3 Site Visit

A site visit was conducted by Dr. Mace Barron on June 5, 2002 and is documented in Appendix D. General observations were made on a walking tour that was escorted by AK Steel representatives. Site visit observations included:

- Dick's Creek was channelized near Monroe Ditch and sediments/flood plain soils had filled the former concrete channel. The flood plain consisted of sandy soils and abundant vegetation that would likely support amphibians and wildlife.

- Racoon and deer tracks were evident near the mouth of Monroe Ditch and a hawk was observed in the riparian area of Dick's Creek.

- Waist high stream debris was observed on a warning sign on the Dick's Creek flood plain near Monroe Ditch, indicating that the creek was subject to high flows.

- Petroleum contamination (rainbow sheen, odor) was evident in Monroe Ditch sediments at the confluence with Dick's Creek.

- Within the AK Steel site, Monroe Ditch had flowing water with multiple pools and riffles and a well developed riparian area. Small birds and dragonflies/damselflies were observed, and several areas of the stream appeared deep enough to support fish. A mallard duck was in Monroe Ditch just upstream of the AK Steel site property.

- Monroe Ditch appeared to have heavy flows at times, as evidenced by waste high stream debris at the stream bank near large rail road culverts at the south boundary of the AK Steel site.

2.3 Contaminant Sources and Transport Pathways

PCBs, PAHs, metals, and other contaminants have been associated with site operations and spills and have been released to Dick's Creek (AquaQual, 2001; Arcadis, 2001a). Potential AK Steel sources of contaminants and transport pathways include facility landfills, outfalls, groundwater seeps and discharges into Dick's Creek and Monroe Ditch, surface runoff, and potential releases to the North Branch of Dick's Creek. Monroe Ditch runs north and west through the south portion of the site, and is adjacent to landfill and slag processing areas. A groundwater interceptor trench was completed in 1998 to capture and treat PCB contaminated groundwater flowing to Monroe Ditch.

All contaminants detected in Dick's Creek sediment, surface water, and biota are presented in Appendix A, and the potential for significant upstream sources of COCs are discussed in Sections 4 and 6 below. High flows are frequent in Dick's Creek following rain events, and suspended sediment during high flows provides an additional contaminant transport process (AquaQual, 2001). Evidence of past high flows in both Monroe Ditch and Dick's Creek was observed during the site visit (Section 2.2).

2.4 Identification of COCs

COCs were identified through a process of comparing the maximum detected concentrations of analytes in sediment, surface water, and biological tissues (plants, benthic invertebrates, fish) to screening toxicity benchmarks for aquatic organisms and wildlife.

2.4.1 Exposure Point Concentrations

As documented in Appendix A, only 1999 or more recent data were screened for Dick's Creek. An exposure point concentration (EPC) was determined from the maximum detected concentration of each analyte in each media (surface sediment, surface water, surface soil), and biota (plants, benthic invertebrates, fish) from the following sources:

- Arcadis (2001a): plant tissue, benthic invertebrate tissue, fish (whole body), sediment, surface water, and flood plain soil (PCBs only).
- AquaQual (2001): benthic invertebrate tissue (indigenous species only) and surface water (in situ measurements were excluded).
- OEPA (2001a,b,c): fish (whole body), sediment, and surface water.

A variety of data sources were used to ensure a comprehensive evaluation because different analytes and analytical methods were utilized by the various monitoring programs in Dick's Creek. Additionally, AqualQual (2001) reported the results of a comprehensive herbicide, insecticide, and fungicide screen in surface water and sediment in Dick's Creek at river miles 5.2 and 2.45. The only detected chemical was at approximate river mile 5.2 for the insecticide chlorpyrifos at 0.008 ug/L, which is substantially below even chronic toxicity levels (Barron and Woodburn, 1995). No volatile organic compounds were detected at approximate river mile 2.45, but PAHs were detected at a total concentration of 0.152 ug/L (AquaQual, 2001).

EPCs for PCBs were determined from the reported total PCB values (e.g., sum of individual congeners or Aroclors). PCB and total PAH (tPAH) concentrations in sediment were normalized to 1% organic carbon prior to screening because the selected sediment screening values (SVs) are applicable to sediment with approximately 1% organic carbon (MacDonald et al., 2000a). If available, maximum dissolved concentrations of metals were used rather than maximum total concentrations because the dissolved form of metals is most associated with toxicity in aquatic organisms.

EPCs were only calculated for detected contaminants, which is reasonable given the broad range of analytes and large number of samples for most media. EPCs for wildlife (prey concentrations) were determined using measured, rather than estimated concentrations, with the only exception being terrestrial wildlife exposures to PCBs. PCB concentrations were estimated in terrestrial prey items (i.e., earthworms, small mammals) using maximum detected surface soil concentrations (0-1 foot) because data for terrestrial biota were not available. Only surface soil data were used because of the standard assumption in ERAs that biota are not exposed to subsurface (> 1 foot) soil contaminants. As shown in Table A6 (Appendix A), PCB concentrations in wildlife prey were estimated using soil to prey bioaccumulation factors (BAF) to convert dry weight sediment concentrations to wet weight prey concentrations.

2.4.2 Screening Values

A Screening Value (SV) for each analyte and media/biota was obtained as follows:

- Wildlife Dietary Benchmarks. The lowest of the lowest observed adverse effect level (LOAEL) wildlife ingestion benchmarks (mg/kg diet) in Sample et al. (1996) was used to separately screen EPCs determined for plants, invertebrates, and fish. Also, tPAH ingestion SVs were derived in Appendix C because (1) PAH exposure and toxicity occurs as mixtures, and (2) appropriate tPAH benchmarks for birds and mammals were not available in Sample et al (1996). LOAEL values were selected rather than no observed adverse effect level (NOAEL) values to focus the ERA on only those contaminants, receptors, and pathways likely to pose risk.

- Sediment. Consensus-based probable effect concentrations were from MacDonald et al. (2000a); the lowest freshwater SV from NOAA (1999) was used if a MacDonald et al. (2000a) SV was not available for an analyte. Probable effect concentrations rather than threshold effect concentrations were selected to focus the ERA on only those contaminants likely to pose risk.

- Surface Water. Chronic AWQC were used as the SV when available because they are derived to be protective of chronic exposures to 95% of aquatic species. The lowest value reported by Suter (1996) was used if an AWQC value was not available.

2.4.3 Hazard Quotient

A hazard quotient (HQ) was determined from the ratio of the EPC and SV: HQ = EPC/SV. All analytes with an HQ greater than one were consider a COC in that media or biota, with only a few exceptions. For example, if total concentrations of a metal in surface water exceeded an HQ of one, the analyte was not considered a COC based on professional judgement because dissolved metal concentrations were likely substantially lower (see Table A5, Appendix A). If an SV was not available for a specific analyte, potential risks were evaluated qualitatively; see Table A5. Also, if an analyte was inconsistently detected and at low levels, it was not considered a COC (e.g., Table A5 of Appendix A). This process of identifying COCs for quantitative evaluation in the BERA is consistent with current USEPA (1997, 2001a, 2001b) guidance on problem formulation and refining COCs. The only COCs were PCBs for specific receptors and pathways, as shown in Table 2.1.

Table 2.1. Summary of Contaminants of Concern.			
Receptor	**Pathway**	**COC**	**Confidence in Results**
Benthic invertebrates	Contact with sediment	PCBs	High confidence: large analyte and sample database
Fish, other aquatic organisms	Contact with surface water	PCBs	High confidence: large analyte and sample database
Herbivorous wildlife	Ingestion of plants	none	Moderate confidence: limited samples and analytes
Piscivorus wildlife	Ingestion of benthic invertebrates	PCBs	Moderate confidence: limited samples and analytes
	Ingestion of fish	PCBs	Moderate confidence: limited samples and analytes
Terrestrial invertebrates	Contact with flood plain soil	none	Low confidence: few samples and analytes
Terrestrial wildlife	Ingestion of soil invertebrates and small mammals	none	Low confidence: no data; only PCBs screened using modeled concentrations in terrestrial prey

2.5 Ecological Exposure and Effects

PCBs were identified as the only COC in Dick's Creek in this problem formulation, and were also considered the principle COC in both of the previous ERAs (AquaQual, 2001; Arcadis, 2001a). Multiple other contaminants including PAHs and metals are present in Dick's Creek and may be elevated from releases from the AK Steel site. However based on the comprehensive risk screening in this problem formulation (Section 2.4), only PCBs are quantitatively evaluated in the BERA for those receptors and pathways identified in Table 2.1. Pathways and receptors with low confidence are qualitatively evaluated in the uncertainty analysis (Section 6.4).

PCBs are known to be persistent, bioaccumulative, and highly toxic to aquatic organisms and wildlife (Eisler, 1986; Barron et al., 1995, 1996). For example, PCBs can cause behavioral abnormalities, impaired reproduction, developmental toxicity, and death in birds and mammals (Barron et al., 1995; Fernie et al., 2001); immune impairment, modulation of hormone levels, and tumors in fish (Barron et al., 2000). As discussed in Section 4 and 5, PCBs occur as complex mixtures of individual congeners including some congeners that cause dioxin-like toxicity (Barron et al., 1994; Eisler and Belisle, 1996). PCB exposure is quantitatively evaluated in Sections 4, and Section 5 presents TRVs and ecological effects of PCBs in Dick's Creek sediment, surface water, and wildlife diets.

2.6 Endpoint Selection and Conceptual Model Description

The assessment endpoints, measurement endpoints, risk questions, and CSM for Dick's Creek are discussed in this section. Assessment endpoints are explicit expressions of the actual environmental values that are to be protected (USEPA, 1998a). Three criteria were used to select assessment endpoints: ecological relevance, susceptibility to known stressors (e.g., sensitive to toxic effects, exposed), and relevance to management goals. Table 2.2 lists the assessment endpoints selected for this ERA, which are focused on the survival, growth, and reproduction of aquatic organisms and wildlife.

Table 2.2. Assessment and Measurement Endpoints and Risk Questions			
Receptor Category	**Assessment Endpoint**	**Measurement Endpoint**	**Risk Question**
Plants	Survival, growth, and reproduction of aquatic plants and flood plain and riparian vegetation	Not evaluated: insufficient data to evaluate risks of PCBs to aquatic and terrestrial plants	NA[1]
Benthic invertebrates	Survival, growth, and reproduction of benthic invertebrate communities	Comparison of sediment concentrations of PCBs to sediment toxicity benchmarks	Are site contaminants in sediments causing risks to benthic invertebrates?
		Qualitative evaluation of site-specific toxicity tests	
		Qualitative evaluation of benthic invertebrate community indices at reference and site areas	
Fish and water column invertebrates	Survival, growth, and reproduction of aquatic organisms	Comparison of surface water concentrations of PCBs to AWQC[2] and aquatic toxicity benchmarks	Are site contaminants in surface water causing risks to fish and water column invertebrates?
		Comparison of fish tissue concentrations of PCBs to tissue residue benchmarks	
Wildlife	Survival, growth, and reproduction of wildlife	Comparison of ingested doses of PCBs to dietary toxicity benchmarks for raccoons, mink, and kingfishers	Are site contaminants in forage and prey causing risks to wildlife?

1. NA: not applicable because assessment endpoint not evaluated.
2. AWQC: chronic freshwater ambient water quality criteria.

Measurement endpoints (measures of effect) are specific metrics that can be quantified to determine the adverse effects of contaminants. Measurement endpoints are listed in Table 2.2 for each category of ecological receptor, and include a comparison of media concentrations to toxicity reference values (TRVs) and comparison of ingested doses of PCBs to TRVs for wildlife. Additional information that was used qualitatively in the weight of evidence evaluation included significant toxicity in aquatic toxicity bioassays, and impairment of ecological health determined from ecological surveys.

A CSM is a written description and visual representation of predicted relationships between ecological entities (i.e., receptors) and stressors (i.e., PCBs), and consist of two principal components: risk hypotheses and a model diagram (USEPA, 1998a). Figure 2.4 presents the CSM, which shows site sources of PCBs (e.g., outfalls, Monroe Ditch), transport pathways (e.g., groundwater discharge), receptors (e.g., fish, wildlife), and exposure routes (e.g., benthic invertebrate contact with sediment; wildlife ingestion of fish) that are quantitatively evaluated in the BERA. The BERA quantitatively evaluates the following receptors and pathways identified in Table 2.1 and Figure 2.4:

- Risks to benthic invertebrates from contact with PCBs in surface sediment;

- Risks to fish from contact/ingestion of PCBs in surface water, sediment, and forage/prey; and

- Risks to piscivorus wildlife ingesting fish, invertebrates, sediment, and surface water contaminated with PCBs.

Conceptual Site Model

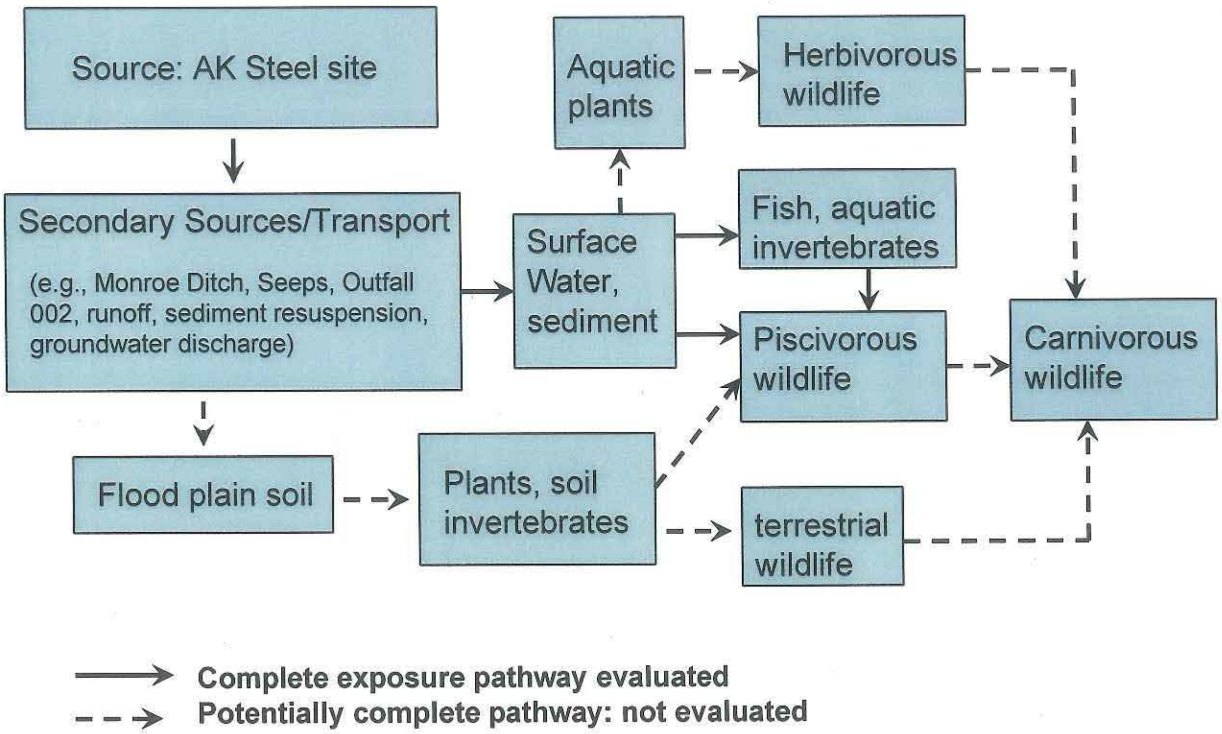

Figure 2.4. Conceptual site model showing pathways quantitatively evaluated for PCB risks to ecological receptors (solid arrows).

The piscivorus wildlife receptors that are quantitatively assessed in this BERA are the raccoon, mink, and belted kingfisher. As discussed in Sections 4 and 5, these species were selected because they are highly exposed (consume contaminated media and biota, have small home ranges), are sensitive to PCBs (particularly mink), and exposure parameters and TRVs are available (USEPA, 2000). Risk hypotheses are specific assumptions about potential risk to assessment endpoints (USEPA, 1998a), and each risk question in Table 2.2 is evaluated in Section 7.

Pathways and receptors that are not quantitatively evaluated are qualitatively evaluated in the uncertainty analysis (Section 6.4) because they were either screened out with low confidence or there were not adequate data to allow a quantitative assessment of risks (Table 2.1). These pathways and receptors were:

- Risks to herbivorous wildlife (e.g., ducks, muskrats) from PCB contaminated aquatic plants;

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- Risks to terrestrial organisms (e.g., earthworms, small mammals, birds) from PCBs in flood plain soils; and

- Risks to top predators (e.g., hawks) from PCBs in prey items (e.g., small mammals, birds).

Site observations (Section 2.2.3) and known PCB releases (e.g., Arcadis, 2001a) indicate that Monroe Ditch may provide PCB exposures to aquatic organisms and wildlife. However, risks of PCBs in Monroe Ditch were only qualitatively evaluated because of a lack of sufficient available exposure data (see Section 4).

2.7 Scientific/Management Decision Point

2.7.1 Risk Management Considerations

USEPA Region 5 requires an objective, quantitative, and comprehensive assessment of ecological risks that incorporates all of the available information and data in a weight of evidence evaluation for Dick's Creek. As discussed in Section 6, a probabilistic assessment was used to quantify risks of PCBs because this approach incorporates uncertainty in exposure and toxicity, and presents a probability of exceeding a risk threshold that can be readily interpreted by risk managers (USEPA, 1999a). Risks were assessed using a protection standard of an approximately 20% effect (e.g., risk estimation using LOAEL TRVs; incorporation of all applicable exposure data) because of the absence of identified special status species and critical habitats. NOAELs would have been used if there were identified threatened and endangered species, critical habitats, or species of special concern in proximity to the site.

2.7.2 Decision to Proceed to a BERA

PCBs were the only COC identified in the problem formulation, and aquatic organisms and piscivorus wildlife were determined to be at risk from PCBs. A BERA is required to quantitatively determine the risks of PCBs in Dick's Creek in proximity to and downstream of the AK Steel site.

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3. Data Used in the ERA

3.1 Overview

Only 1999 or more recent data are used from three sources: AK Steel (Section 3.2), WSU/AquaQual (Section 3.3), and OEPA (Section 3.4). The lone exception is the use of large fish data collected in 1998 by Arcadis (2001a); see Section 3.2 below.

3.2 AK Steel Data

AK Steel data quantitatively used in assessing ecological risks consisted of information provided in the following documents:

- Arcadis. 2002a. *Floodplain Soil and Supplemental Sediment Sampling and Analysis Plan.* Arcadis G&M, Inc. Prepared for AK Steel Corp. February 13, 2002.
- Arcadis. 2001a. *Ecological Risk Assessment for Dick's Creek. Arcadis G&M, Inc.* Prepared for AK Steel Corp. June 1, 2001.
- Arcadis. 2001b. *Addendum 1 to the Ecological Risk Assessment for Dick's Creek, PCBs in Surface Versus Subsurface Sediments.* Arcadis G&M, Inc. Prepared for AK Steel Corp. July 10, 2001.
- Arcadis. 2001c. *Addendum 2 to Ecological Risk Assessment: Background Risks.* Arcadis G&M, Inc. Prepared for AK Steel Corp. July 11, 2001.

Data included PCB concentrations in sediment, surface water, seeps, flood plain soil, aquatic plants, benthic invertebrates, and fish collected in 1999 and 2000. The only exception is the use of two data points for large fish collected in 1998 that are used in assessing critical body residue risks to fish; these data are not used in assessing wildlife risks. AK Steel data are described in Section 4.

3.3 WSU/AquaQual Data

The WSU/AquaQual data that are quantitatively used in assessing ecological risks consisted of information provided in the following document:

- AqualQual. 2001. *Ecological Risk Assessment of Dick's Creek, Middletown, Ohio.* AquaQual Services, Inc. Prepared for Tetra Tech. April 30, 2001. [including CDROM "WSU era dat" containing files: "Dick's new ERA data.xls", "Arcadis Response 82201.doc", and "WSU ERA DATABASE.xls"]

A total of 10 reported PCB measurements were used quantitatively in the BERA: five indigenous benthic invertebrate samples collected between 1999 and 2000, and five surface water samples collected in 2000. These data are described in Section 4. Other information from the AquaQual (2001) report are used qualitatively in the weight of evidence and uncertainty analysis of the BERA (Section 6), and include in situ bioassays performed in 1999 and 2000, and an ecological survey performed in 2000.

3.4 OEPA Data

OEPA data quantitatively used in assessing ecological risks consisted of the following information:

- OEPA. 2001. *Ohio EPA Summary of AK Steel Seeps Found During Deep Inspections Starting November 2000 - October 2001, per USEPA 7003 Order.* Ohio EPA data sheets.

- OEPA. 2000a. *Laboratory Organic Analysis Data Reports.* Ohio EPA. [sediment samples collected August, 2000].

- OEPA. 2000b. *Laboratory Organic Analysis Data Reports, Laboratory Inorganic Analysis Data Reports, and Tissue Sample Submission Forms.* Ohio EPA. [fish samples collected November, 2000].

- OEPA. 2000c. *Laboratory Organic Analysis Data Reports, and Laboratory Inorganic Analysis Data Reports.* Ohio EPA. [water samples collected July to September, 2000].

Data included PCB concentrations in sediment, surface water, seeps, and fish collected in 2000. These data are described in Section 4.

4. Exposure Analysis

4.1 Overview

PCBs were produced as commercial mixtures (e.g., Aroclors) of a hundred or more individual polychlorinated biphenyl congeners (Eisler, 1986). The environmental fate, exposure, and toxicity of PCBs can be dependent on the congener composition of the PCB mixture, and some PCB congeners can cause dioxin-like toxicity at substantially lower levels than total PCB concentrations (Barron et al., 1994; Eisler and Belisle, 1996). The congener composition of a commercial PCB mixture will change once it enters the environment because of differential partitioning, degradation, and bioaccumulation of the PCB congener components of the mixture. On a homolog basis (i.e., sum of PCB congeners with the same number of chlorine atoms), PCBs in Dick's Creek sediment resemble Aroclor 1242, but also contain higher chlorinated congeners (Figure 4.1). The homolog composition of PCBs in benthic invertebrates and fish appear to resemble Aroclor 1248 more than Aroclor 1242, which may be caused by environmental and biological processes.

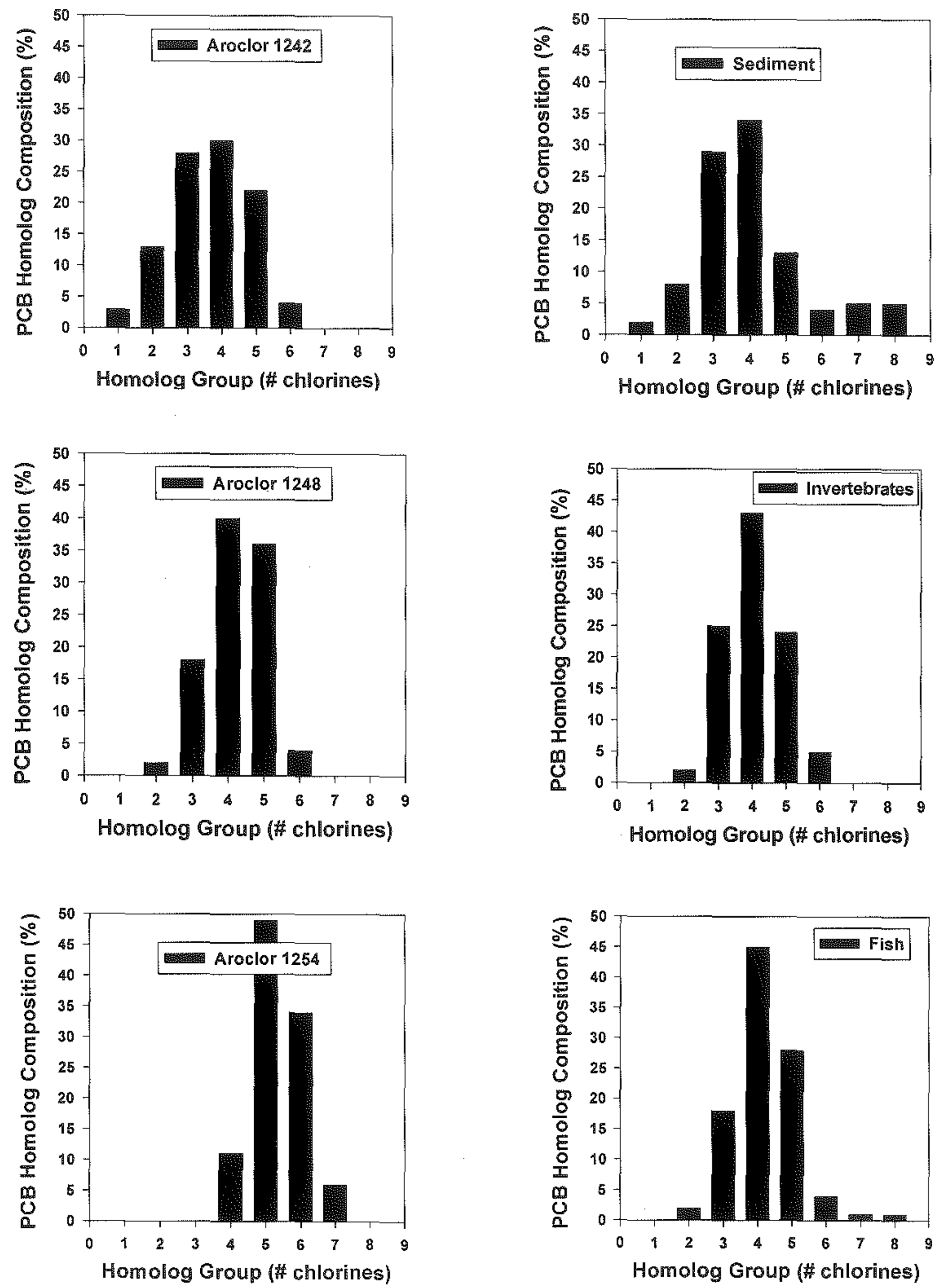


Figure 4.1. PCB homolog composition in commercial Aroclor mixtures and Dick's Creek sediment, invertebrates, and fish. Data source: Arcadis (2001a; Table 4-7).

Only total PCB data are used quantitatively in the BERA because:

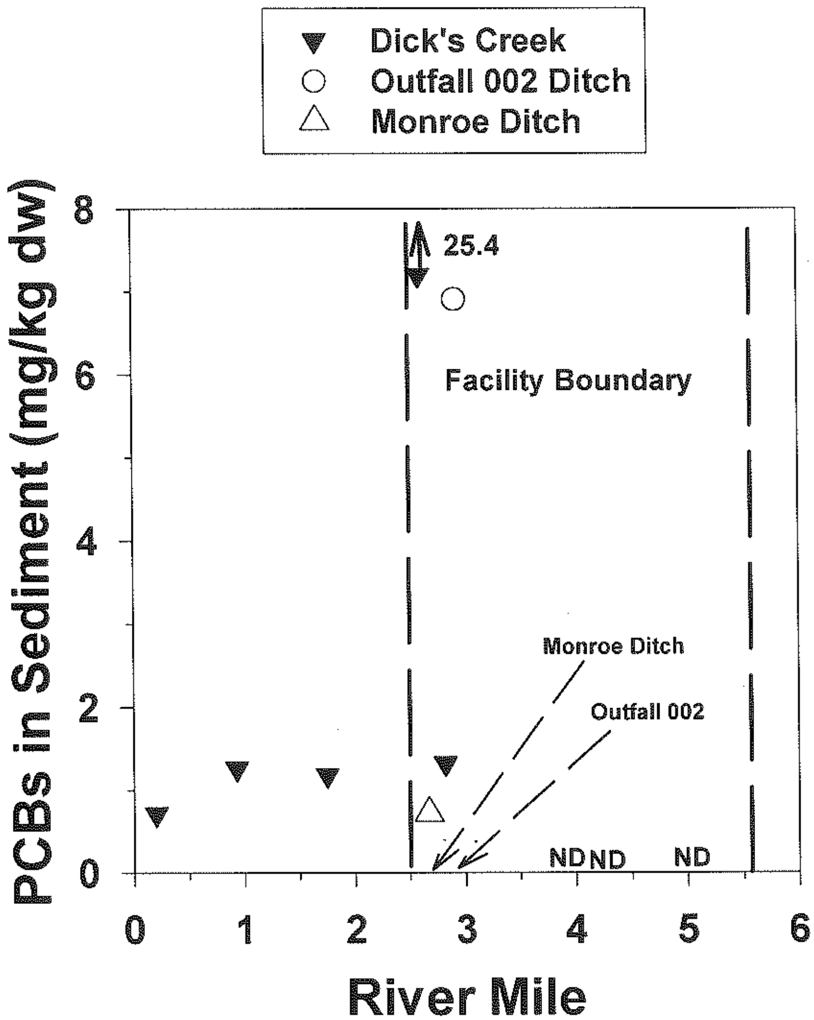
- PCB congener data are only available in AquaQual (2001) for a limited number of locations and sample types (sediment, surface water, benthic invertebrates).

- Congener specific toxicity to aquatic organisms and wildlife is only understood for a relatively few PCB congeners, and congener interactions are poorly understood (e.g., the potential for synergism or antagonism from dioxin-like and non-planar congeners is relatively unknown).

- As discussed below, there is an abundance of high quality total PCB data in environmental media and biota of Dick's Creek. Also, as noted in Section 5, peer-reviewed TRVs for total PCBs are available for all of the ecological receptors evaluated in this BERA.

Exposure data are provided in Appendix E and in Figures 4.2 to 4.6, and are summarized in Table 4.1. All sediment data are for surface samples on a dry weight (dw) basis, and are reported as either mg/kg sediment or mg/kg normalized to 1% sediment organic carbon. Biological tissue data are presented as mg/kg wet weight tissue (ww). Exposure and toxicity of dioxin-like congeners are evaluated qualitatively in the uncertainty evaluation (Section 6.4).

This section summarizes contaminant concentrations in sediment (Section 4.2), surface water (Section 4.3), flood plain soil (Section 4.4), and biota tissues (Section 4.5). Section 4.6 provides the methodology and parameters used in modeling wildlife ingestion, Section 4.7 discusses background levels of PCBs in Dick's Creek, and Section 4.8 summarizes trends in PCB exposure.



Data source: (OEPA, 2000)
ND: not detected

Figure 4.2. PCBs in Dick's Creek sediment (closed symbols) and facility discharge ditch sediment (open symbols). Data Source: OEPA (2000a)

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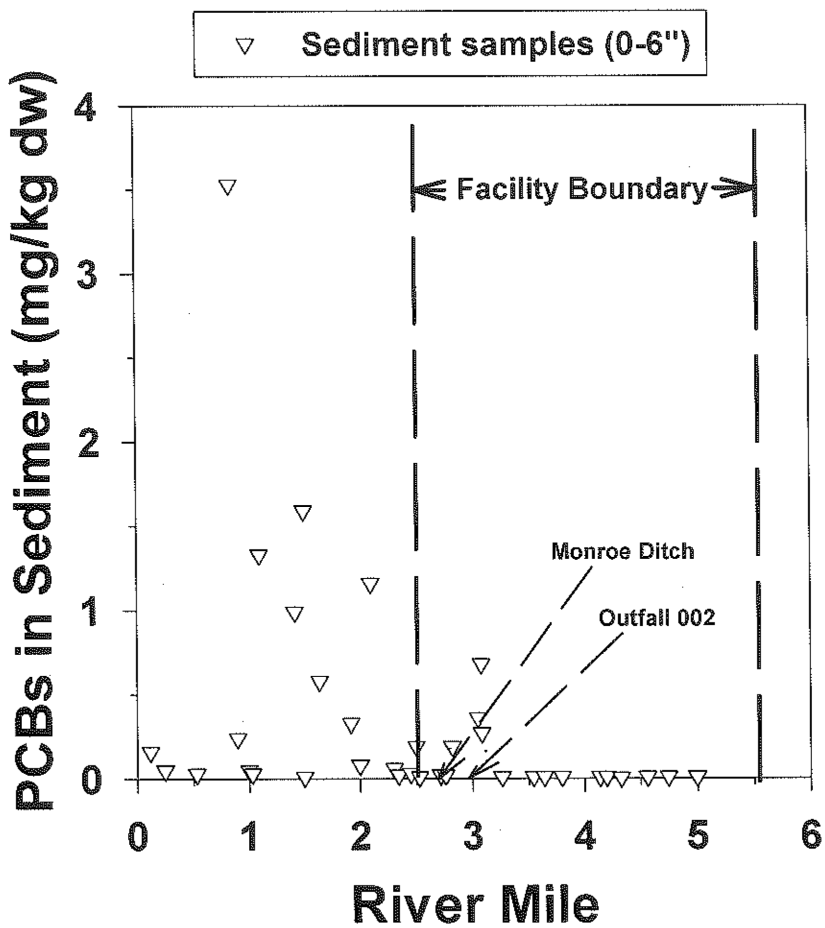


Data source: Table 3 (Arcadis, 2001b)

Figure 4.3. PCBs (mg/kg dw) in sediment samples (0-6 inches) in Dick's Creek sampled between September 2000 and February 2001 (normalized to 1% organic carbon). Data source: Arcadis (2001b)

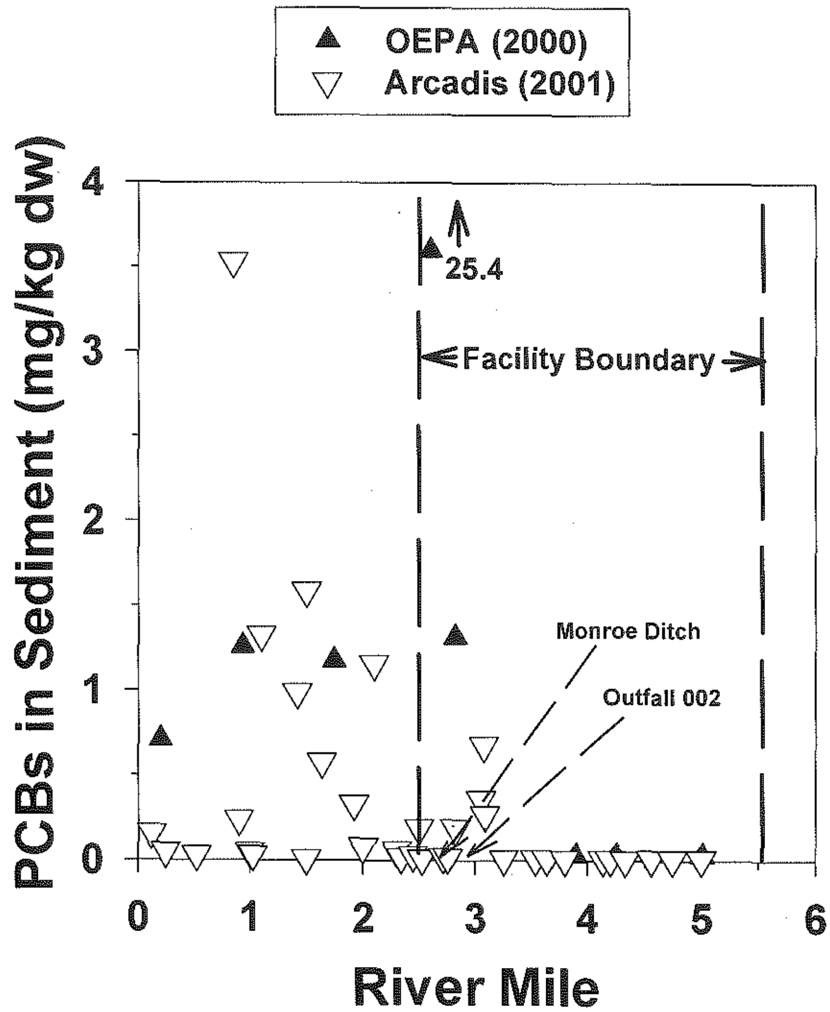
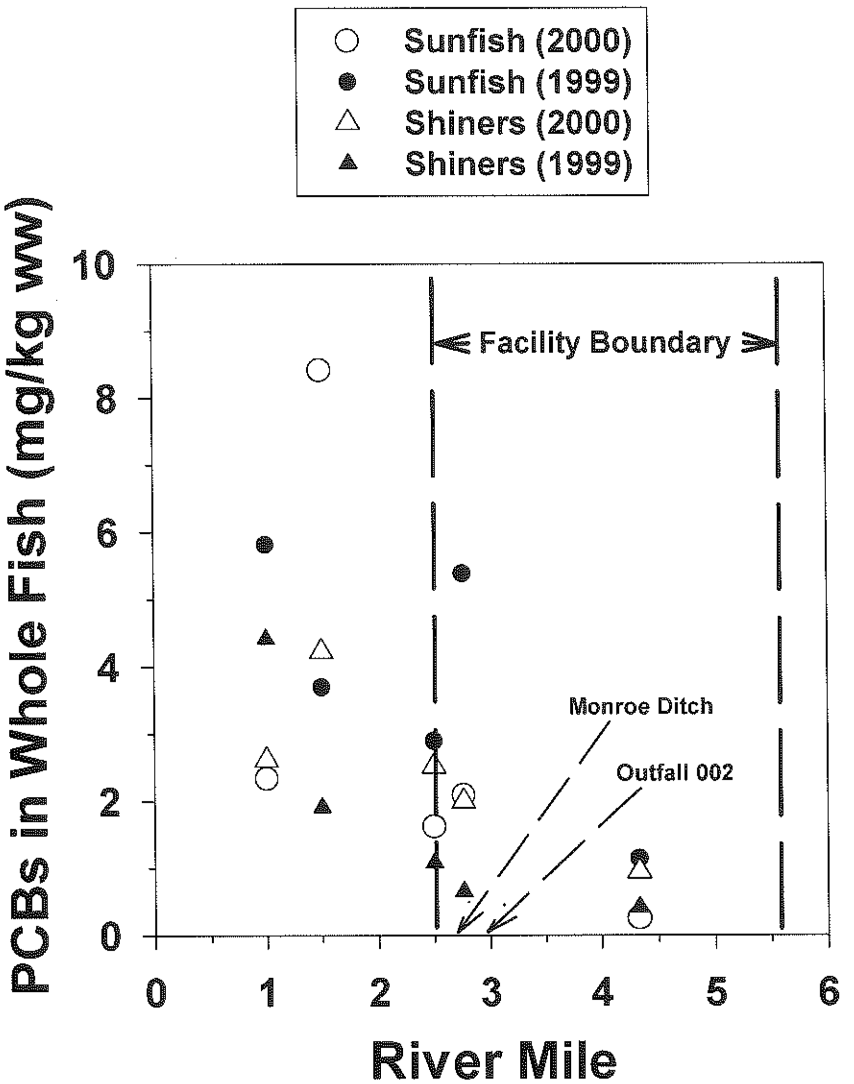
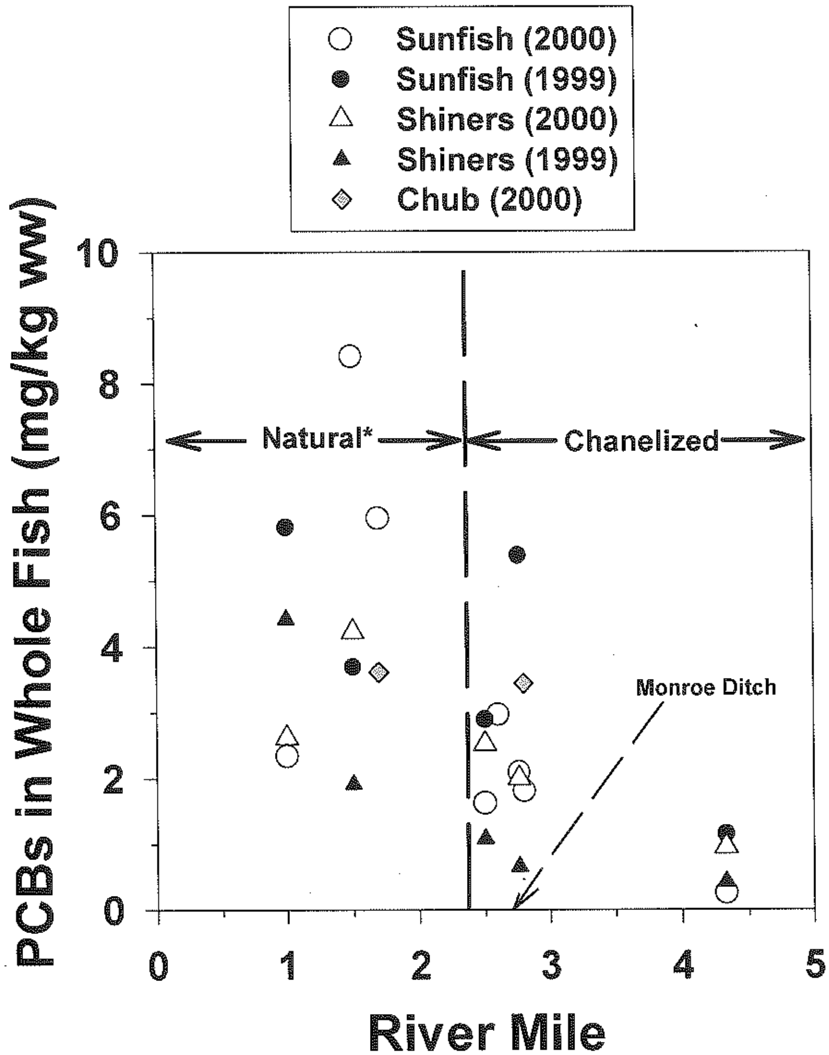


Figure 4.4. Combined OEPA (2000a) and Arcadis (2001b) surface sediment data for Dick's Creek (normalized to 1% organic carbon).



Data source: Table B-11 (Arcadis, 2001)

Figure 4.5. PCBs in whole fish. Shiners: Spotfin shiners; Sunfish: longear sunfish and green sunfish. Data Source: Arcadis (2001b)



Data source: (OEPA, 2000b; Arcadis, 2001)

Figure 4.6. Combined OEPA (2000b) and Arcadis (2001a) whole body PCB data for spotfin shiners, sunfish (longear, green), and creek chub in natural and channelized sections of Dick's Creek. *Approximately 0.2 miles near river mile 1 is channelized. (Arcadis, 2001a).

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Table 4.1. P CB Exposure Data and Probability Distribution Functions Used in Risk Calculations.					
Media/Biota	**Units**	**PCBs[1]**			
		Mean (SD)	**Min-Max**	**n**	**Distribution**
Sediment (total)[2]	mg/kg dw	2.19 (7.60)	0.03-48.2	40	log-normal
Sediment (1% OC)[3]	mg/kg dw	1.03 (4.01)	0.004-25.4	40	log-normal
Surface water[4]	mg/L	NC[4]	0 - 0.00007	5	uniform
Invertebrate[5]	mg/kg ww	0.663 (0.807)	0.011 - 2.46	15	log normal
Fish (≤ 14 cm)[6]	mg/kg ww	2.64 (1.71)	0.421 - 5.96	22	log normal
Small-medium[7] fish	mg/kg ww	2.89 (1.98)	0.421 - 8.42	25	log normal
All fish[8]	mg/kg ww	3.73 (4.04)	0.421 - 22.9	34	log normal

1. SD: standard deviation; Min-Max: minimum-maximum values; n: sample size; Distribution: probability distribution used in assessing wildlife risks.
2. Used in assessing wildlife risks from incidental sediment ingestion.
3. Normalized to 1% organic carbon (OC); used in assessing risks to benthic invertebrates.
4. Used in assessing wildlife risks from consumption of Dick's Creek surface water. NC: not calculated because of limited data; all other recent surface water results within Dick's Creek are non-detects with elevated detection limits (e.g., 0.0001 mg/L).
5. Used in assessing wildlife risks from ingestion of benthic invertebrates.
6. Whole body fish data used in assessing risks to kingfishers.
7. Whole body fish data used in assessing risks to mink and raccoons (excludes large fish species: e.g., carp, bass, bullhead, sucker).
8. Whole body fish data used in assessing risks to fish from accumulation of critical body residues.

4.2 Sediment

PCB concentrations in Dick's Creek sediments ranged from 0.03 to 48.2 mg/kg and were used in assessing risks to piscivorus wildlife from incidental ingestion (Section 4.6). PCB concentrations normalized to 1% organic carbon ranged from 0.004 to 25.4 mg/kg and were used in assessing risks to benthic invertebrates. Figure 4.2 shows the spatial distribution of PCBs in sediment using Arcadis (2001a) data, and Figure 4.3 shows the spatial distribution of PCBs using combined Arcadis (2001a) and OEPA (2000a) data. Both figures show substantially increasing PCBs downstream of Outfall 002 and Monroe Ditch. PCB concentrations in Monroe Ditch near the confluence with Dick's Creek have been as high as 8 mg/kg (1% organic carbon; Arcadis, 2002a), and 7 mg/kg in Outfall 002 sediment (OEPA, 2000a).

Only surface sediment data were used in the BERA, but subsurface sediments contain higher concentrations of PCBs (Arcadis, 2001a). Observations from the June 5, 2002 site visit (Section 2.2.3) indicated that Dick's Creek is subject to high flows and substantial sediment movement as indicated by the width of the flood plain and the vertical extent of debris on flood plain vegetation. This suggests the potential for resuspension of the PCBs that are buried in Dick's Creek sediment.

4.3 Surface Water

Surface water data for PCBs are extremely limited because the majority of samples have been analyzed using elevated detection limits (e.g., 0.2 ug/L) relative to chronic AWQC (0.014 ug/L). The PCB surface water data reported by OEPA (2000c) and Arcadis (2001a) were all non-detected values. The only available low detection limit PCB analyses in surface water were reported by AqualQual (2001) as a sum of individual congeners for samples collected in June and August, 2000:

- river mile 5.2: 0 ug/L (not detected; detection limit not reported)
- river mile 2.45: 0.026 and 0.04 ug/L
- river mile 1.63: 0.019 and 0.070 ug/L

Both OEPA (2001) and Arcadis (2002b) have reported PCBs in seeps located on the south bank of Dick's Creek along the AK Steel site:

- Seep #10: 0.66 to 1.35 ug/L
- Seep #16: south bank 0.3 ug/L
- Seep #22: south bank 0.58 to 0.7 ug/L

Seeps in Monroe Ditch have also have been reported to contain PCBs (e.g., Seeps #11 and #12: 6.18 to 8.89 ug/L; Arcadis, 2002c).

Together, these data indicate that PCBs in surface water increase below apparent site sources of Outfall 002, Monroe Ditch, and PCB contaminated groundwater seeps.

4.4 Flood Plan Soil

Data for PCBs in flood plain soil are not adequate for a use in a quantitative evaluation of risks to soil dwelling organisms and terrestrial invertebrates, and were only used in the COC screening (Section 2.4). The limited soil data (six sample locations) show that PCBs have been detected in surface soil (maximum detection of 0.17 mg/kg), and increase at a depth of 2 to 4 feet (1.6 mg/kg soil; Arcadis, 2002a). PCBs have also been detected in flood plain soil during trenching operations near Monroe Ditch at very high levels (e.g., 210 mg/kg; AK Steel, 2002a). AK Steel (2001) also reported total PCBs concentrations of 1.172 mg/L in water infiltrating the trench, which exceeds the water solubility of Aroclor 1242 (240 ug/L; Eisler, 1986). These data indicate that high levels of PCBs are present in the subsurface in proximity to Monroe Ditch, but there are inadequate data to evaluate the spatial extent of contamination and ecological risks of PCBs in the flood plain of Dick's Creek. Observations from the June 5, 2002 site visit (Section 2.2.3) indicated that Dick's Creek is subject to high flows and substantial sediment movement as indicated by the width of the flood plain and the vertical extent of debris on flood plain vegetation. This suggests the potential for transport of PCBs between Dick's Creek sediment and its flood plain.

4.5 Biota

4.5.1 Plants

Table E2 (Appendix E) shows that PCB concentrations in aquatic plants ranged from non-detections (<0.01 mg/kg) to 0.284 mg/kg (ww), and that concentrations were higher in August 2000 than in October 1999 and increased downstream of Outfall 002. These data (8 samples) were not used quantitatively in the BERA because the COC screening (Section 2.4) indicated herbivorous wildlife were not at risk.

4.5.2 Invertebrates

Table E3-1 (Appendix E) shows that PCB concentrations in benthic invertebrates ranged from 0.011 to 2.46 mg/kg (ww) in samples collected in 1999 and 2000. Although different species were sampled, both AqualQual (2001) and Arcadis (2001a) data show a similar trend of low level PCB contamination in invertebrates above Outfall 002 (0.011 and 0.04 mg/kg) and maximum values of 2 to 2.5 mg/kg downstream of Monroe Ditch.

Table E3-2 shows that dioxin-like PCB congeners were generally not detectable upstream of Outfall 002, whereas dioxin-like PCBs had maximum values of 0.029 mg/kg downstream of Outfall 002. The dioxin-like potency of these congeners are listed in Table E3-3. PCB congener data are only used qualitatively in the BERA (Section 6).

4.5.3 Fish

Concentrations of PCBs in fish are summarized in Table 4.1 by the fish size groups used in the BERA as follows:

- small fish ($\leq$ 14 cm). PCBs (0.4 - 6 mg/kg) were used in assessing risks to belted kingfisher because this species feeds on a maximum size fish of 14 cm. For example, USEPA (1993) noted that kingfishers will feed 13 cm fish to two week old nestlings. Davis (1982) reported that 6 to 12 cm fish were the dominant size consumed by kingfishers feeding in a southwestern Ohio, but they also consume 12 to 14 cm fish. Scott and Crossman (1973) noted that kingfishers consumed creek chubs, which was one of the medium size fish species included in the database (Tables E4-1 and E4-2).

- small-medium fish. PCBs (0.4 - 8.4 mg/kg) were used in assessing risks to mink and raccoon because these species will feed on moderately sized fish.

- all fish. This group included all sizes of fish (PCBs range of 0.4 - 22.9 mg/kg) and was only used in assessing risks to fish from accumulated body residues of PCBs.

Figure 4.5 shows the spatial distribution of PCBs in small (spotfin shiners) and medium (sunfish) sized fish using Arcadis (2001a) data, and demonstrates that PCBs substantially increase in fish downstream of Outfall 002 and Monroe Ditch. Statistical analysis (Analysis of Variance) of PCB concentrations in fish indicated there was no significant change in PCB concentrations in fish collected by Arcadis (2001a) in 1999 and 2000.

Figure 4.6 shows the spatial distribution of PCBs using combined Arcadis (2001a) and OEPA (2000b) data (includes creek chub and additional sunfish samples). This figure demonstrates that PCBs increase downstream of the AK Steel site, and also shows that the highest levels of PCBs in fish are present in or in close proximity to the natural portions of Dick's Creek. This is important because fish consumption by piscivorus wildlife may be higher in the natural sections of Dick's Creek, leading to higher exposures than modeled in the BERA.

4.6 Wildlife Ingestion Modeling

For each wildlife receptor, an average daily dose (ADD) was calculated using a simple dietary exposure model, adapted from USEPA (2000), as well as standard references sources (e.g., Sample et al., 1996):

ADD = ADDdiet + ADDwater + ADDsediment

Table 4.2 and the following equations define the model parameters and equations:

ADDwater = (PCBsw x WI)*AUF/BW

ADDsediment = (PCBsediment x FS x IRdry)*AUF/BW

ADDdiet = (PCBfish*PDfish+PCBinvert*PDinvert)*IRwet*AUF/BW

Table 4.2. Wildlife Exposure Model Parameter Definitions.			
Parameter	**Units**	**Definition**	**Source**
ADD	mg/kg*d	average total daily ingested dose of PCBs	calculated
ADDdiet	mg/kg*d	average daily ingested dose of PCBs in diet	calculated
ADDwater	mg/kg*d	average daily ingested dose of PCBs in drinking water	calculated
ADDsediment	mg/kg*d	average daily ingested dose of PCBs from incidental sediment ingestion	calculated
PCBsw	mg/L	PCBs in surface water	AquaQual (2001)
WI	L/d	water ingestion rate	Appendix B
AUF	unitless	area use factor	Appendix B
BW	kg (ww)	body weight	Appendix B
PCBsediment	mg/kg (dw)	PCBs in sediment	Appendix E
FS	unitless	incidental sediment ingestion (fraction of diet)	Appendix B
IRdry	kg/d (dw)	total food ingestion rate	Appendix B
PCBfish	mg/kg (ww)	PCBs in fish	Appendix E
PDfish	unitless	proportion of diet as fish	Appendix B
PCBinvert	mg/kg (ww)	PCBs in invertebrates	Appendix E
PDinvert	unitless	proportion of diet as invertebrates	Appendix B

Plant PCBs were not included in the ADD equations because the assessed receptors did not consume plants. Appendix B provides the exposure parameters for kingfisher (Table B1), raccoon (Table B2), and mink (Table B3). The majority of exposure parameters were determined from USEPA (2000) because they have been comprehensively evaluated for the Hudson River ERA, and were considered appropriate for the Dick's Creek ERA. For example, the home range of kingfisher determined by USEPA (2000) was 0.7 km, similar to the 0.39 to 1 km home range determined for kingfishers in a southwestern Ohio stream (Davis, 1982). A uniform distribution of ranges of parameters were used in the risk characterization (Section 6) if multiple values were reported by USEPA (2000); e.g., range of body weights for female and male animals.

An area use factor (AUF) is a parameter used to lower wildlife exposure by the fraction the receptor may feed outside of the affected site habitat (AH). For example, an AUF of 0.7 indicates the receptor would only be exposed throughout 70% of its home range (HR). An AUF was estimated for each receptor from the spatial extent of the AH and the HR for each wildlife receptor: AUF = AH/HR. Home ranges were determined from species-specific information (Appendix B), and the size of the affected habitat was determined as described below.

A kingfisher and mink AH of 8 km was computed from an estimated 5 river miles of affected habitat. A raccoon AH of 49 hectares was calculated from an estimated 5 river miles of affected habitat with an average width of 0.037 miles that included flood plain and riparian areas. In comparison, AquaQual (2001) noted that channelized sections of Dick's Creek had established riparian areas in proximity to AK Steel (e.g., 20 to 40 meters beyond the controlled grassy areas). Natural sections of Dick's Creek had riparian zones up to 100 meters on both banks of the creek. Photographs taken during the June 2000 site visit also show riparian areas in the channelized section of Dick's Creek in proximity to AK Steel (Appendix D).

Exposure duration (ED; Appendix B) is a factor that accounts for any migration or hybernation/estivation that would reduce exposure below that needed to cause adverse effects. The ED was defined as one for all species in the BERA because they are anticipated to be exposed for a duration that is applicable to the TRVs used to characterize risks. Because ED was set with a value of one, it does not appear in the above equations.

4.7 Background Levels of PCBs

Arcadis (2001c; Table 2-2) reported PCB concentrations in sediments in "upstream background areas" for Dick's Creek. PCBs were only detected in 3 of 23 samples at 0.03 to 0.04 mg/kg (normalized to 1% OC). In comparison, mean organic carbon normalized sediment PCBs in the affected reach of Dick's Creek was 1 $\pm$ 4 mg/kg (Table 4.1). The three reported Arcadis (2001c) detections in upstream areas were all in samples collected in proximity to the north boundary of the AK Steel site, and thus the appropriateness as a background location is uncertain. OEPA (2000a) had no detections of PCBs in Dick's Creek sediments at three locations above Outfall 002. Together these data further indicate that PCBs are low or not detectable above AK Steel sources of PCBs.

4.8 Trends in PCB Exposure

Multiple AK Steel sources of PCBs exist along the site boundary, including contaminated groundwater, Outfall 002 sediment, and Monroe Ditch. The available data show that PCBs substantially increase in surface water, sediment, aquatic plants, benthic invertebrates, and fish below these sources. PCB contamination has been detected for over three miles of Dick's Creek, to nearly its confluence with the Great Miami River, and the available recent data (1999+) do not show any apparent declines in PCB concentrations.

5. Effects Analysis

5.1 Overview

This section summarizes the adverse effects information for PCBs in Dick's Creek, including TRVs (Section 5.2), site-specific toxicity testing (Section 5.3), and ecological survey results (Section 5.4). As discussed below, TRVs were primarily obtained from the Hudson River ERA (USEPA, 2000) because they have been rigorously evaluated and are applicable to assessing risks in Dick's Creek. For example, USEPA (2000) notes that 80% of the PCB released to the Hudson River since 1955 were Aroclor 1242, and Aroclor 1242 appears to be the predominant PCB mixture at the AK Steel site. Table 5.1 lists the TRVs used in this BERA.

Table 5.1. TRVs for PCBs.[1]

Receptor	Pathway	TRV	Effect Level	Source
Benthic invertebrates	Sediment	0.34 (mg/kg dw)	Median	MacDonald et al. (2000b)
Fish	Body residue	1.9 - 9.3 (mg/kg)	Range of NOAEL and LOAEL[2]	Tables 4-25a (USEPA, 2000)
Belted kingfisher	Ingestion	7.1 (mg/kg*d)	LOAEL	Table 4-26a (USEPA, 2000)
Raccoon	Ingestion	0.15 - 1.5 (mg/kg*d)	Range of LOAELs	Table 4-27a,b (USEPA, 2000)
Mink	Ingestion	0.04 - 0.3 (mg/kg*d)	Range of LOAELs	Table 4-27a (USEPA, 2000)

1. Units in mg PCBs per kg body weight (ww), except for sediment (mg/kg dry weight sediment).
2. Range of NOAEL and LOAEL values for multiple fish species.

5.2 Toxicity Reference Values

5.2.1 Media TRVs

The sediment TRV was 0.34 mg/kg, which is the consensus median effect level for PCBs in freshwater sediment from MacDonald et al. (2000b). This value differs slightly from the USEPA (2000) value because the 0.4 mg/kg TRV selected for the Hudson River was applicable to both freshwater and marine sediments.

A soil TRV was not determined for the BERA because of insufficient data to determine exposure (Section 4). The applicable surface water TRV is the chronic AWQC value of 0.014 ug/L.

5.2.2 Fish Critical Body Residue TRVs

Because of the limited surface water data, PCB effects on fish were determined using a critical body residue (CBR) approach CBRs are known to be highly variable (Barron et al., 2001), but USEPA (2000) determined a range of PCB tissue residues of 1.9 to 9.3 mg/kg to be appropriate TRVs for evaluating the adverse effects of PCBs on a variety of fish species. This range of TRVs was used in assessing risks to fish in Dick's Creek.

5.2.3 Wildlife TRVs

Wildlife TRVs were determined from the species-specific LOAELs presented in USEPA (2000). Mink are recognized as among the most sensitive mammalian species to PCBs (e.g., Brunstrom et al., 2001), and had an ingestion TRV range of 0.04 - 0.3 mg/kg*d that was 4 to over 100 times lower (more sensitive) than the kingfisher (7.1 mg/kg*d) and raccoon (0.15 - 1.5 mg/kg*d).

5.3 Site-Specific Toxicity Testing

AquaQual (2001) performed both laboratory and in situ (in stream) toxicity testing in Dick's Creek and considered the situ data to be more sensitive and apparently more representative of PCB toxicity in Dick's Creek. The results of in situ toxicity tests conducted in 1999 and 2000 that were summarized by AqualQual (2001) included:

- high mortality in sediment and pore water exposures of aquatic invertebrates at locations downstream of the site.
- significant correlations between survival and PCB concentrations in surficial sediments.
- the highest mortality in the in situ chamber water exposures occurred at the highest water concentrations of PCBs.

These results are discussed in the weight of evidence and uncertainty analysis (Section 6), but are not used to quantify risks to benthic invertebrates.

5.4 Ecological Surveys

The most recent reported ecological surveys of Dick's Creek have been performed by Arcadis (2001a) and AquaQual (2001) in 2000. The results of these surveys are discussed below, and in Section 6, but are not used to quantify risks to ecological receptors.

AquaQual (2001) considered the Dick's Creek stream habitat to be of adequate quality, but survey results indicated poor quality benthic and fish communities. For example, few species of macroinvertebrates were present, pollution tolerant species dominated, and there was evidence of high bivalve mortality (AqualQual, 2000).

A quantitative 2000 ecological survey (Attachment D of Arcadis, 2001a; summarized in Table 5.2) indicated that (1) Dick's Creek in proximity to and downstream of AK Steel had very poor to good habitat, (2) that two of these sample locations did not meet biological criteria scores for macroinvertebrates, and (3) all locations met fish criteria.

Table 5.2. Summary of Dick's Creek Ecological Survey Results for 2000 (Arcadis, 2001a)[1].

River Mile[2] (station number)	Habitat Quality	Benthic Invertebrate	Fish
6.3 (6)[2]	poor	non-attainment	non-attainment
5 (2)	fair	met criteria	met criteria
4.4 (3)	fair	met criteria	met criteria
3 (4)	very poor	non-attainment	met criteria
2.6 (5)[3]	fair	non-attainment	met criteria
0.6 (10)	good	met criteria	met criteria

1. Source: Attachment D Arcadis (2001a): Biological Survey of Dick's Creek and its Tributaries, 2000.
2. Upstream of the AK Steel site.
3. Station 3 inconsistently cited as river mile 2.4 or 2.6.

6. Risk Characterization

6.1 Overview

PCBs risks to benthic invertebrates, fish, and piscivorous wildlife were identified in the problem formulation (Section 2). A probabilistic assessment of PCB risks was used because it incorporates the variability and uncertainty in exposure and toxicity, and provides directly interpretable risk descriptions for risk managers (USEPA, 1999a). Point estimate approaches were used in both the two previous risk assessments for Dick's Creek (Arcadis, 2001a; AqualQual, 2001), but differed in both the characterization and conclusions regarding PCB risks to aquatic life and wildlife because of the assumptions and interpretations applied in the risk assessments.

This section presents the methods and results of the risk estimation (Section 6.2), the risk description and weight of evidence evaluation (Section 6.3), and the uncertainty analysis (Section 6.4).

6.2 Risk Estimation

Risks were estimated as a probability distribution of hazard quotients (HQ = [PCBs]/TRV) in simulations with Latin Hypercube sampling (10,000 iterations) using @Risk software (Palasade Corporation). PCB exposure (PCBs) was determined from the probability distribution function (e.g., mean, standard deviation; log normal distribution) listed in Table 4.1. TRVs were defined as the point value or uniform distribution of ranges listed in Table 5.1. Table 6.1 lists the results of the risk estimation, including the ranges of PCB exposures, HQs, and percentages of risk exceedences that were determined in risk simulations.

Table 6.1. Ranges of Exposure and Risks of PCBs to Aquatic Organisms and Wildife Feeding in Dick's Creek.				
Receptor	**Pathway**	**PCB Exposure[1]**	**Hazard Quotient**	**% Exceedences[2]**
Benthic invertebrates	Sediment	<0.001 - 25.2 (mg/kg dw)	0.001 - 73.5	43.1%
Fish[3]	Bioaccumulation	0.059 - 22.7 (mg/kg ww)	0.016 - 10.9	23.7%
kingfisher	Ingestion[4]	0.102 - 7.61 (mg/kg*d)	0.014 - 1.07	<1%
raccoon	ingestion	0.007 - 2.45 (mg/kg*d)	0.005 - 3.76	<1%
mink	ingestion	0.018 - 1.15 (mg/kg*d)	0.092 - 14.4	43.5%

1. Range of PCB concentrations; exposure units shown in parentheses.
2. Percent of HQs exceeding a value of 1 indicative for population level effects.
3. Based on critical body residues.
4. Includes ingestion of fish, invertebrates, and water. Also includes incidental sediment ingestion by raccoon and mink.

The results of the risk estimation for aquatic organisms and wildlife were (Table 6.1):

- Benthic invertebrates were at risk from PCBs in sediments, with HQs ranging from 0.001 to 73.5, and a probability of exceeding median effect concentrations of 43%.

- Fish were at risk from PCBs bioaccumulated in their tissues, with HQs ranging from 0.02 to 10.9, and a probability of exceeding CBR toxicity levels of 23.7%.

- Kingfishers were not at risk from ingestion of PCBs, with HQs ranging from 0.01 to 1.1, and a probability of exceeding ingestion TRVs of less than 1%.

- Raccoons were not at risk from ingestion of PCBs, with HQs ranging from 0.005 to 3.8, and a probability of exceeding ingestion TRVs of less than 1%.

- Mink were at risk from ingestion of PCBs, with HQs ranging from 0.09 to 14.4, and a probability of exceeding ingestion TRVs of 43.5%.

6.3 Risk Description and Weight of Evidence Evaluation

6.3.1 Benthic Invertebrates

Probabilistic risk estimates indicate that benthic invertebrates are at risk from contact with PCB contaminated sediment in Dick's Creek. Figure 6.1 compares the spatial distribution of PCBs in sediment [normalized to 1% organic carbon; data from OEPA (2000a)] to medium and severe effects levels for benthic invertebrates. This figure shows that toxic levels of PCBs exist downstream of the AK Steel site (e.g., river mile 2.5), but toxicity in upstream locations is unlikely. This figure also shows that sediment PCBs in the Outfall 002 ditch and Monroe Ditch are also present at toxic levels. Figure 6.2 shows combined OEPA (2000a) and Arcadis (2001a) sediment PCB data, and demonstrates a similar trend of exceedences of medium and severe toxicity levels below the site, and unlikely toxicity above Outfall 002.

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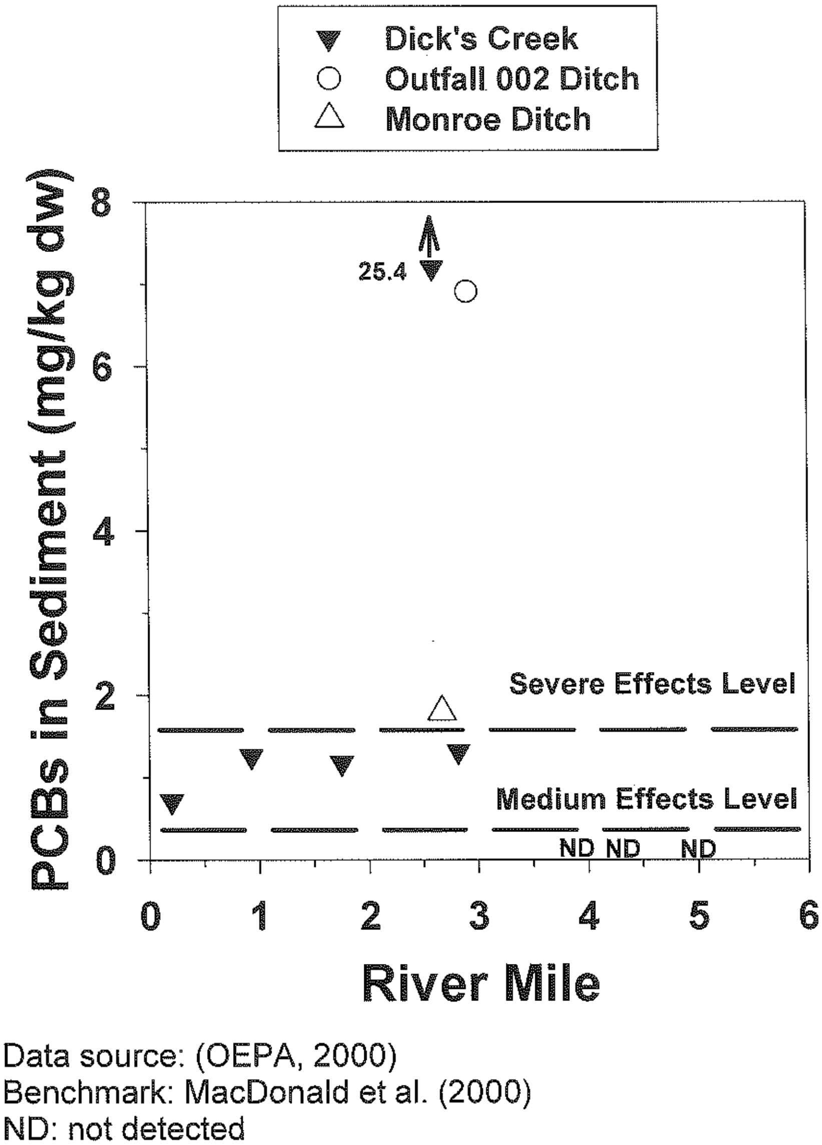

Figure 6.1. Comparison of sediment PCB concentrations (OEPA, 2000a) to medium and severe freshwater sediment effect levels (MacDonald et al., 2000b).

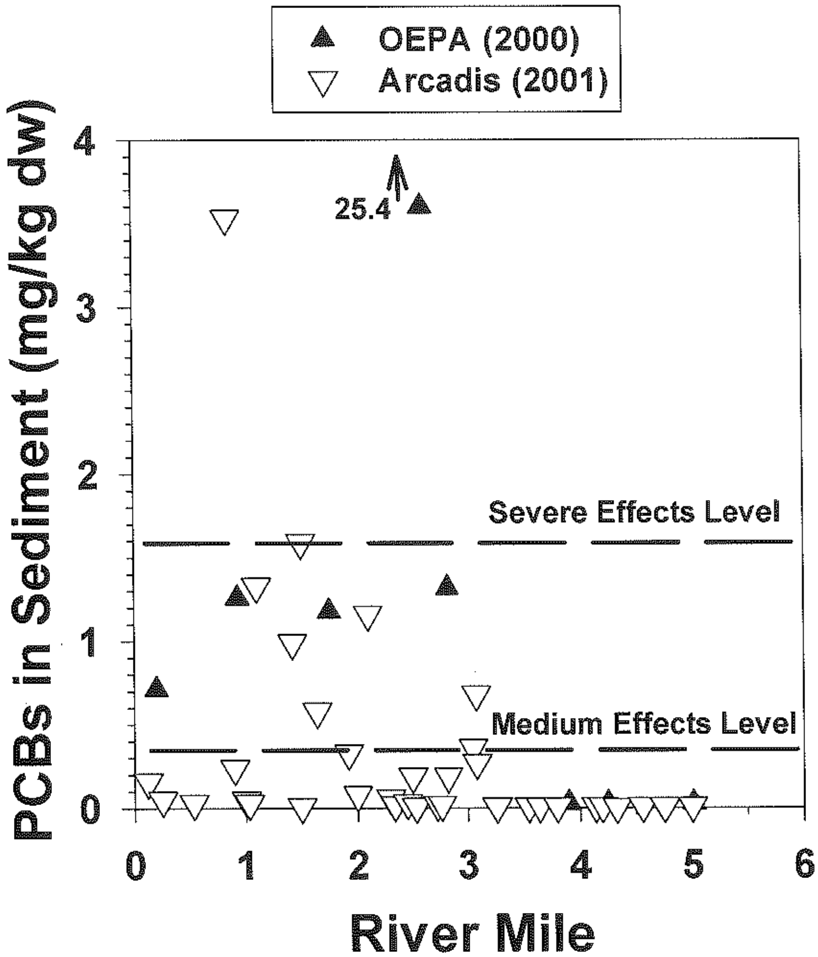

Figure 6.2. Comparison of PCBs in Dick's Creek sediment [combined OEPA (2000a) and Arcadis (2001b)] to sediment effect levels (MacDonald et al., 2000b).

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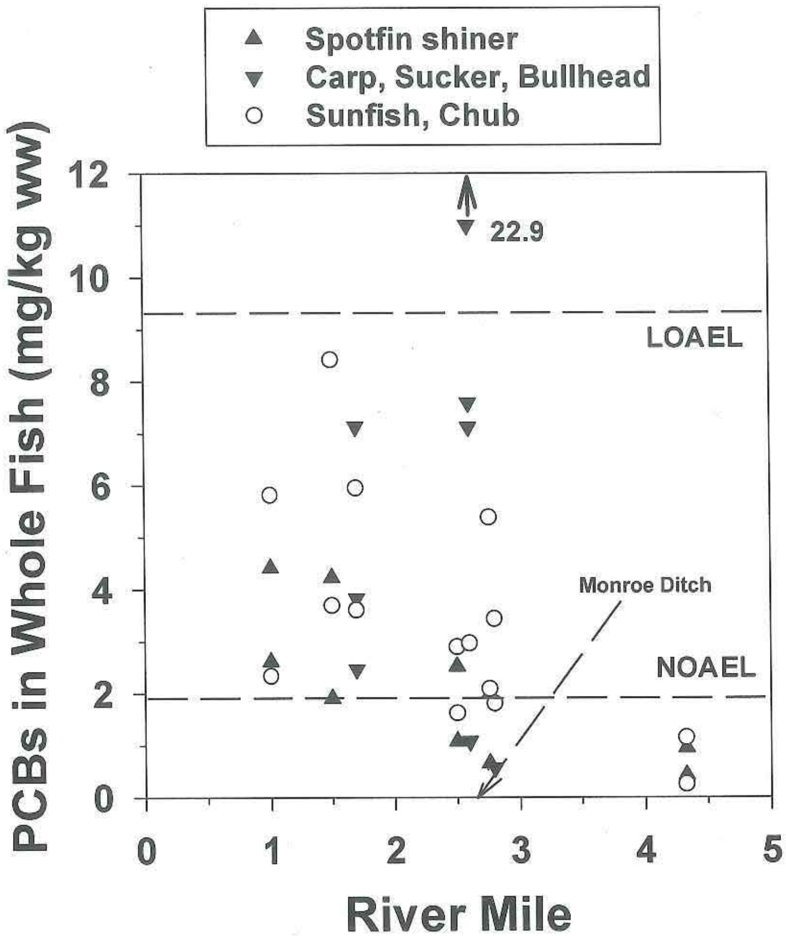
These observations are also consistent with site-specific toxicity test results (AquaQual, 2001) and ecological surveys (AquaQual, 2001; Arcadis, 2001a). For example, AquaQual (2001) reported mortality in sediment, pore water, and water column exposures of aquatic invertebrates at locations downstream of the site, and significant correlations between survival and PCB concentrations in surficial sediments. Both AquaQual (2001) and Arcadis (2001a) reported an impaired benthic community at locations below the AK Steel site. In the Arcadis (2001a) survey performed in 2000, the only location with fair to good habitat quality that did not meet ecological criteria for benthic invertebrate communities was at approximate river mile 2.45 downstream of the AK Steel site.

The available lines of evidence show that benthic invertebrates are at substantial risk from PCBs in sediments from the AK Steel site. This conclusion is considered to be of high confidence because the spatial extent of PCBs has been well characterized, and risks were determined using TRVs indicative of population level effects.

6.3.2 Fish

Probabilistic risk estimates indicate that fish are at risk from bioaccumulation of PCBs in Dick's Creek. Figure 6.3 compares the spatial distribution of PCBs in fish to NOAEL and LOAEL critical body residue values for PCBs. This figure shows that toxic levels of PCBs exist near Monroe Ditch and locations downstream of the AK Steel site. This figure also demonstrates that fish tissue concentrations of PCBs are below no effect levels upstream of Outfall 002. Surface water concentrations of PCBs also exceeded AWQC downstream of the AK Steel site, but are not detectable at upstream locations.



Data source: (OEPA, 2000b; Arcadis, 2001)
Benchmark Source: Table 25a of EPA (2000)

Figure 6.3. Comparison of whole body fish tissue concentrations to tissue based TRVs for fish. Combined data from Arcadis (2001a) and OEPA (2000b).

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The available lines of evidence show that fish are at substantial risk from PCBs that have been released into Dick's Creek from the AK Steel site. This conclusion is considered to be of high confidence because the spatial extent of PCBs bioaccumulation has been well characterized in fish, and risks were determined using TRVs indicative of adverse effects on a variety of fish species.

6.3.3 Wildlife

Probabilistic risk estimates indicate that mink are at risk from PCBs in Dick's Creek, but raccoons and kingfishers are not at risk. The conclusion of substantial risks to mink is considered to be of high confidence because of the high probability of exceeding TRVs indicative of population level effects (i.e., TRVs derived from LOAEL rather than NOAEL values). The conclusions regarding raccoon and kingfishers have only moderate confidence because PCB exposure and risks may be underestimated:

- Raccoons were assumed to only derive PCB exposures from Dick's Creek; i.e., consistent with USEPA (2000), ingestion modeling assumed that 60% of prey were derived from non-stream sources. Portions of the flood plain of Dick's Creek are known to be contaminated with PCBs and may contribute to PCB exposures in raccoons, but information was not adequate to assess this pathway.

- Kingfishers were assumed to derive their PCB exposure from contaminated fish in both the natural and channelized sections of Dick's Creek As noted previously, fish contamination is higher in the natural sections (Figure 4.6), and risks may be higher to kingfishers preferentially feeding in these areas.

6.4 Uncertainty Analysis

6.4.1 Receptors and Exposure Pathways

As discussed in Section 6.3, PCB exposure and risks may be underestimated to raccoons and kingfishers. PCB exposures in the Dick's Creek flood plain were not incorporated because of inadequate data, and wildlife may selectively feed in the natural stream sections that also contain the most contaminated benthic invertebrate and fish prey species.

Several categories of receptors were not quantitatively evaluated in the BERA, either because they were screened out with low confidence or there were not adequate data to allow a quantitative assessment of risks (Table 2.1). Exclusion of these pathways and receptors represent a substantial uncertainty in the BERA, and indicate the potential to underestimate ecological risks:

- Aquatic plants. Surface water exposure data for aquatic plants was limited and plant TRVs for PCBs have not been well established.

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- Terrestrial plants. Surface soil exposure data for terrestrial plants was limited and TRVs for PCBs have not been well established.

- Amphibians and reptiles. There was insufficient information to characterize risks to amphibians and reptiles, and TRVs have not been well established.

- Soil invertebrates. Surface soil exposure data for soil dwelling invertebrates was limited and TRVs for PCBs have not been well established.

- Risks to herbivorous wildlife (e.g., ducks, muskrats). Data on PCB contamination in aquatic plants was limited but did not exceed SVs (Section 2).

- Risks to terrestrial small mammals and birds. Data on PCB contamination in terrestrial plants and soil invertebrates were not available. Estimated PCB concentrations in earthworms did not exceed SVs.

- Risks to top predators (e.g., hawks). Data on PCBs in prey items (e.g., terrestrial and aquatic small mammals and birds) were not available. Estimated PCB concentrations in terrestrial small mammals did not exceed SVs (Section 2).

6.4.2 Monroe Ditch

PCB risks in Monroe Ditch were not quantitatively assessed because of insufficient available information, which was limited to seep monitoring, and sediment and surface water concentrations at one upstream location and at the confluence with Dick's Creek. High levels of PCBs detected in sediment at the mouth of Monroe Ditch suggest the potential for risks at upstream locations within the AK Steel site. Habitat for both aquatic organisms and wildlife were evident during the June 2002 site visit (Appendix D), thus complete exposure pathways and receptors are likely present.

6.4.3 PCB Congeners

The BERA only quantitatively evaluated risks from total PCB exposures, but toxic dioxin-like congeners are known to be present in the Dick's Creek system downstream of the AK Steel site (AquaQual, 2001) The dioxin-like congeners measured in indigenous invertebrates in Dick's Creek (Table E3-2) indicate that fish and wildlife are exposed to these congeners, which are known components of commercial Aroclors. Risks may be underestimated from only a total PCB assessment (Barron et al., 1994; USEPA, 2000).

6.4.4 Background Risks

Background risks appear to be low or non-existent in Dick's Creek, as evidenced by non-detections or very low contamination measured in surface water, sediment, aquatic plants, benthic invertebrates, and fish upstream of AK Steel PCB source areas.

7. Summary and Conclusions

7.1 Summary of the BERA

This report assesses the risks of AK Steel site contaminants to ecological receptors using and inhabiting Dick's Creek. A BERA was performed according to current USEPA guidance, including problem formulation, analysis of exposure and effects, and risk characterization (USEPA, 1997, 1998a, 2001a, 2001b).

<u>Problem Formulation</u>

Dick's Creek is a small stream in southwest Ohio that has received PCBs and other contaminant releases from the AK Steel site in Middletown, Ohio. Dick's Creek generally flows east to west to its confluence with the Great Miami River and is in proximity to the AK Steel site from approximately river miles 2.5 to 5.5.

A HQ approach was used to identify COCs using a systematic and moderately conservative screening process of comparing maximum detected contaminant concentrations and LOAEL screening values. Exposure point concentrations were only calculated for detected contaminants using 1999 or more recent data, and non-detected analytes were excluded from consideration. Wildlife risks were determined using measured prey concentrations; only PCBs in terrestrial prey were estimated because no data were available.

PCBs were identified as the only COC in Dick's Creek for the following receptors and exposure pathways: (1) benthic invertebrate contact with sediment, (2) fish contact with surface water and accumulation of toxic body residues, and (3) piscivorous wildlife ingestion of surface water, benthic invertebrates, fish, and sediment (incidental). The mink, raccoon, and belted kingfisher were selected as piscivorous wildlife receptors because they are highly exposed (consume contaminated media and biota; have small home ranges), are sensitive to PCBs (particularly mink), and exposure parameters and TRVs were available (USEPA, 2000). Other PCB exposure pathways and ecological receptors were either screened out with low confidence or there were not adequate data to allow a quantitative assessment of risks; these were qualitatively evaluated in the uncertainty analysis.

Analysis of PCB Exposure and Effects

Only 1999 or more recent data for surface water, sediment, groundwater seeps, flood plain soils, and biota were used from three sources: AK Steel/Arcadis, WSU/AquaQual, and OEPA. The lone exception was the use of data for two samples of large fish collected in 1998 by Arcadis (2001a). Only surface sediment data were considered in this BERA, and PCB concentrations were normalized to 1% organic carbon for the assessment of risks to benthic invertebrates.

Multiple AK Steel sources of PCBs exist along the site boundary, including contaminated groundwater seeps, Outfall 002 sediments, and Monroe Ditch. The available data consistently show that PCBs substantially increase in surface water, sediment, aquatic plants, benthic invertebrates, and fish below these source areas. PCBs are low or not detectable above these areas. PCB contamination has been detected for over three miles in Dick's Creek to nearly its confluence with the Great Miami River, and the available recent data (1999+) do not show any apparent declines in PCB concentrations.

TRVs were obtained primarily from USEPA (2000) because they have been rigorously evaluated and are applicable to assessing risks in Dick's Creek. Risks were assessed using a protection standard of an approximately 20% effect (e.g., risk estimation using LOAEL TRVs; incorporation of all applicable exposure data) because of the absence of identified special status species and critical habitats.

Risk Characterization

A probabilistic assessment was used to estimate PCB risks to benthic invertebrates, fish, and piscivorous wildlife because this approach incorporated the variability and uncertainty in exposure and toxicity, and provided directly interpretable risk descriptions for risk managers.

The available lines of evidence show that benthic invertebrates are at substantial risk from PCBs in Dick's Creek sediment downstream of AK Steel PCB source areas. This conclusion is considered to be of high confidence because the spatial extent of PCBs has been well characterized, and risks were determined using TRVs indicative of population level effects. HQs ranged from 0.001 to 73.5, and the probability of exceeding median effect concentrations was 43%. Additionally, a qualitative evaluation of the results of recent ecological surveys and in situ toxicity tests also indicated adverse effects of contaminated sediments.

The available lines of evidence show that fish are at substantial risk from PCBs in Dick's Creek downstream of AK Steel PCB source areas. This conclusion is considered to be of high confidence because the spatial extent of PCB bioaccumulation has been well characterized in fish, and risks were determined using TRVs indicative of adverse effects on a variety of fish species. HQs ranged from 0.02 to 10.9, and the probability of exceeding toxic levels of critical body residues of PCBs was 23.7%. The limited low detection data for PCBs in surface water indicated that chronic AWQC was exceeded downstream of the AK Steel site.

Probabilistic risk estimates indicate that mink are at risk from ingestion of PCBs, with HQs ranging from 0.09 to 14.4, and a probability of exceeding ingestion TRVs of 43.5%. The conclusion of substantial risks to mink is considered to be of high confidence because of the high probability of exceeding TRVs indicative of population level effects (i.e., TRVs derived from LOAEL rather than NOAEL values).

Kingfishers and raccoons were not at risk from ingestion of PCBs, with probabilities of exceeding ingestion TRVs of less than 1%. The conclusions regarding raccoon and kingfishers have only moderate confidence because PCB exposure and risks may be underestimated. PCB exposures derived from the Dick's Creek flood plain were not incorporated because of inadequate data, and wildlife may selectively feed in the natural stream sections that contain the most contaminated benthic invertebrate and fish prey species.

Background risks appear to be negligible in Dick's Creek, as evidenced by non-detections or very low contamination measured in surface water, sediment, aquatic plants, benthic invertebrates, and fish upstream of AK Steel PCB source areas.

Uncertainty Analysis

Several categories of ecological receptors were not quantitatively evaluated in this BERA, either because they were screened out with low confidence or there were not adequate data to allow a quantitative assessment of risks. Exclusion of these pathways and receptors represent a substantial uncertainty in the BERA, and indicate the potential to underestimate ecological risks for aquatic and terrestrial plants, amphibians and reptiles, soil invertebrates, terrestrial small mammals and birds, wildlife primarily feeding on aquatic plants (e.g., muskrats), and top predators such as hawks.

There were insufficient data to quantitatively assess the risks of PCBs in the soils of the Dick's Creek flood plain, or the potential future risks from resuspension and transport of PCBs in the Dick's Creek system. The limited available data indicate that high levels of PCBs are present in the subsurface in proximity to Monroe Ditch. Also, subsurface sediments contain higher concentrations of PCBs (Arcadis, 2001a), although only surface sediment data were used in the BERA. Observations from a June 5, 2002 site visit indicated that Dick's Creek is subject to high flows and substantial sediment movement as indicated by the width of the flood plain and the vertical extent of debris on flood plain vegetation. This suggests the potential for resuspension of the PCBs that are buried in Dick's Creek sediment, and the potential for transport of PCBs between Dick's Creek sediment and its flood plain.

PCB risks in Monroe Ditch were not quantitatively assessed because of insufficient available information, which was limited to seep monitoring data, and sediment and surface water concentrations at a location upstream of the site and near the confluence with Dick's Creek. High levels of PCBs detected in sediment at the mouth of Monroe Ditch suggest the potential for risks at upstream locations within the AK Steel site. Habitat for both aquatic organisms and wildlife were evident during the June 2002 site visit (Appendix D), thus complete exposure pathways and receptors are likely present.

An additional source of uncertainty is the potential for risks from the complex mixtures of contaminants in Dick's Creek (e.g., additive toxicity), and any unmeasured contaminants that were not analytes.

7.2 Conclusions

Risk Questions

This section evaluates each of the risk questions presented in Table 2.1.

Are site contaminants in sediments causing risks to benthic invertebrates?

The weight of evidence indicates that PCBs in sediments are causing risks to benthic invertebrates downstream of AK Steel source areas of PCBs. The evidence includes a high probability of exceeding medium effects levels, and indications that the benthic invertebrate community is impaired and sediments are toxic, downstream of the AK Steel site. Risks to benthic invertebrates in Monroe Ditch were not assessed, but may be significant as indicated by high PCB levels near the confluence with Dick's Creek and likely complete exposure pathways.

Are site contaminants in surface water causing risks to fish and water column invertebrates?

The weight of evidence indicates that PCBs are causing risks to fish downstream of AK Steel sources of PCBs. The evidence includes a high probability of fish bioaccumulating critical body residue levels of PCBs, and surface water concentrations of PCBs that exceed chronic Ambient Water Quality Criteria downstream of the AK Steel Site. Risks to fish or water column invertebrates in Monroe Ditch were not assessed, but may be significant as indicated by high PCB levels near the confluence with Dick's Creek and likely complete exposure pathways.

Are site contaminants in forage and prey causing risks to wildlife?

A probabilistic assessment of risks indicates that PCBs are causing risks to mink downstream of AK Steel source areas of PCBs. Other species of piscivorous wildlife (belted kingfisher, raccoon) were determined to not be at risk. PCBs increase in the forage and aquatic prey of wildlife (aquatic plants, benthic invertebrates, fish) downstream of the AK Steel site, and the highest levels of PCBs in fish are present in or in close proximity to the natural portions of Dick's Creek. Risks to wildlife may be underestimated because PCB exposure in piscivorous wildlife may be higher in the natural sections of Dick's Creek where wildlife may preferentially feed. Risks may also be underestimated because the potential for flood plain PCB exposures was not considered in assessing risks to raccoons and mink, and terrestrial wildlife risks were not quantitatively evaluated because of insufficient data. Wildlife risks from Monroe Ditch were not assessed, but may be significant as indicated by high PCB levels near the confluence with Dick's Creek and likely complete exposure pathways.

Risks to aquatic and terrestrial plants and soil dwelling invertebrates were not assessed because of insufficient data and lack of well established TRVs.

Conclusions

Aquatic organisms and wildlife are at risk from PCBs in Dick's Creek downstream of the AK Steel PCB site source areas. In contrast, PCB levels are low or non-detectable upstream of AK Steel PCB site source areas and are unlikely to pose risks to aquatic organisms and wildlife.

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Appendix A

Determination of Contaminants of Concern (COCs)

Overview

This Appendix provides a rapid screening of contaminants detected by Arcadis (2001a), OEPA (2000a,b), and AquaQual (2001) to determine contaminants of concern (COCs) in the baseline ecological risk assessment (BERA). This process eliminates contaminants unlikely to pose significant risks at the site and allows the BERA to focus on the risk drivers. Risks are screened by media and biological tissue category below using maximum detected concentrations and lowest observed adverse effect level (LOAEL) screening values (listed in each table below).

A1. Plants

Table A1. Maximum Detected Contaminant Concentrations in Aquatic Plants from Dick's Creek (mg/kg ww) Compared to Wildlife Screening Values (mg/kg ww).[1]					
Analyte	**Maximum Concentration**	**Source**	**Screening Value[2]**	**Hazard Quotient**	**COC?[4]**
PCBs	0.284	Arcadis (2001) Table B-5	0.71	<1	No
total PAHs	0.205	Arcadis (2001) Table B-3	20[3]	<1	no
Cadmium	0.029	Arcadis (2001) Table 3-6	16.6	<1	no
Chromium	0.44	Arcadis (2001) Table 3-6	4.1	<1	no
Lead	1.1	Arcadis (2001) Table 3-6	9.4	<1	no
Nickel	2.5	Arcadis (2001) Table 3-6	89	<1	no
Silver	0.0068	Arcadis (2001) Table B-4	NA[5]	NC[5]	no[5]
Zinc	20	Arcadis (2001) Table 3-6	109	<1	no

1. Maximum detected concentration in available data sources.
2. Lowest of the LOAEL (lowest observed adverse effect level) reported in Table 12 of Sample et al. (1996), unless otherwise noted.
3. Wildlife screening value derived in Appendix C.
4. COC: contaminant of concern if hazard quotient > 1.
5. Benchmark not available (NA) and hazard quotient not calculable (NC). Not considered a COC because all metal toxicity benchmarks generally exceed 1 mg/kg (i.e., silver unlikely to be toxic at detected level).

A2. Benthic Invertebrates

Table A2. Maximum Detected Contaminant Concentrations in Benthic Invertebrates from Dick's Creek (mg/kg ww) Compared to Wildlife Screening Values (mg/kg ww).[1]

Analyte	Maximum Concentration	Source	Screening Value[2]	Hazard Quotient	COC?[4]
PCBs	2.5[7]	Arcadis (2001) Table 3-7	0.71	3.5	yes
total PAHs	4.62[6]	AquaQual (2001)	20[3]	<1	no
Cadmium	0.023	Arcadis (2001) Table 3-9	16.6	<1	no
Chromium	0.69	Arcadis (2001) Table 3-9	4.1	<1	no
Copper	23	Arcadis (2001) Table 3-9	51.1	<1	no
Lead	0.28	Arcadis (2001) Table 3-9	9.4	<1	no
Nickel	2.0	Arcadis (2001) Table 3-9	89	<1	no
Silver	0.105	Arcadis (2001) Table B-7	NA[5]	NC[5]	no[5]
Zinc	23	Arcadis (2001) Table 3-9	109	<1	no

1. Highest value reported in AquaQual (2001), Arcadis (2001), or by OEPA (2000a,b) shown.
2. Lowest of the LOAEL (lowest observed adverse effect level) reported in Table 12 of Sample et al. (1996), unless otherwise noted.
3. Wildlife screening value derived in Appendix C.
4. COC: contaminant of concern if hazard quotient > 1.
5. Benchmark not available (NA) and hazard quotient not calculable (NC). Not considered a COC because all metal toxicity benchmarks generally exceed 1 mg/kg (i.e., silver unlikely to be toxic at detected level).
6. Corbicula samples reported in "Dick's new ERA data" Excel database. Higher PAH values (15.9 mg/kg) are reported for in situ exposures but are lower than laboratory control tissue.
7. Excludes in situ exposures with higher PCB values (e.g., 7.4 mg/kg) in AquaQual (2001) because of PCBs detected in laboratory control tissue (e.g., 1 mg/kg).

A3. **Fish**

Table A3. Maximum Detected Contaminant Concentrations in Whole Fish from Dick's Creek (mg/kg ww) Compared to Wildlife Screening Values (mg/kg ww).[1,5]					
Analyte	**Maximum Concentration**	**Source**	**Screening Value[2]**	**Hazard Quotient**	**COC?[4]**
PCBs	8.415[5]	Arcadis (2001) Table 3-10	0.71	11.9	yes
Dieldrin	0.005	OEPA (2000b)	0.74	<1	no
g-Chlordane	0.050	OEPA (2000b)	8.9	<1	no
total PAHs	0.196	Arcadis (2001) Table 3-10	20[3]	<1	no
Arsenic	0.0418	OEPA (2000b)	2.5	<1	no
Cadmium	0.037	OEPA (2000b)	16.6	<1	no
Chromium	1.0	Arcadis (2001) Table 3-9	4.1	<1	no
Copper	2.2	Arcadis (2001) Table 3-9	51.1	<1	no
Lead	0.133	OEPA (2000b)	9.4	<1	no
Mercury	0.0376	OEPA (2000b)	0.053[5]		
Nickel	0.82	Arcadis (2001) Table 3-9	89	<1	no
Selenium[5]	0.162	OEPA (2000b)	0.66[5]	<1	no
Zinc	83	Arcadis (2001) Table 3-9	109	<1	no

1. Excludes larger fish species (e.g., carp, sucker, bullhead, bass).
2. Lowest of the LOAEL (lowest observed adverse effect level) reported in Table 12 of Sample et al. (1996), unless otherwise noted.
3. Wildlife screening value derived in Appendix C.
4. COC: contaminant of concern if hazard quotient > 1.
5. Screening value is for most toxic form (i.e., methylmercury, alkyl-selenium).

A4. Sediment

Table A4. Maximum Detected Contaminant Concentrations in Sediment from Dick's Creek (mg/kg dw) Compared to Sediment Screening Values (mg/kg dw).					
Analyte	**Maximum Concentration**	**Source**	**Screening Value[2]**	**Hazard Quotient**	**COC?[4]**
PCBs	52.1[1]	Arcadis (2001) Table 5-1	0.676	77	yes
total PAHs	10.0[1,3]	Arcadis (2001) Table B-2	22.8	<1	no
g-chlordane	0.0465	OEPA (2000)	17.6[5]	<1	no
Aldrin	0.0005	OEPA (2000)	40[5]	<1	no
Arsenic	13.8	OEPA (2000)	33	<1	no
Aluminum	14,950	Arcadis (2001) Table 3-2	25,500[5]	<1	no
Barium	100	OEPA (2000)	NA[9]	NC[9]	no[9]
Cadmium	1.27[6]	Arcadis (2001) Table 3-2	4.98	<1	no
Chromium	37	OEPA (2000)	111	<1	no
Copper	65.1	Arcadis (2001) Table 3-2	149	<1	no
Iron	19,600	OEPA (2000)	40,000[5]	<1	no
Lead	62[6]	Arcadis (2001) Table 3-9	128	<1	no
Manganese	760	OEPA (2000)	630	1.2	no[7]
Mercury	0.073	OEPA (2000)	1.06	<1	no
Nickel	33.1	Arcadis (2001) Table 3-2	48.6	<1	no
Silver	0.3	Arcadis (2001) Table 3-2	4.5[5]	<1	no
Strontium	247	OEPA (2000)	NA[9]	NC[9]	no[9]
Titanium	61.7	OEPA (2000)	NA[9]	NC[9]	no[9]

Zinc	664	OEPA (2000)	459	1.4	no[8]

1. Normalized to 1% organic carbon content.
2. Screening values are probable effects concentrations from MacDonald et al. (2000a).
3. Sum of detected polycyclic aromatic hydrocarbon (PAH) analytes.
4. COC: contaminant of concern if hazard quotient > 1.
5. Lowest freshwater screening value in NOAA (1999).
6. Reported as simultaneously extracted metal (SEM; reported total metal values are higher). Highest total lead reported in OEPA (2000) 38.3 mg/kg.
7. Not considered a COPC because only one detection exceeded screening value (River Mile 0.93) and hazard quotient near 1.
8. Not considered a COPC because only two detections exceeded screening value (River Mile 0.93 and 5.01) and both hazard quotients near 1. Maximum Arcadis (2001) SEM value was below screening value.
9. Benchmark not available (NA) and hazard quotient not calculable (NC). Not considered a COC because shows minimal exceedence of marine threshold (HQ 2.08).

A5. Surface Water

Table A4. Maximum Detected Contaminant Concentrations in Surface Water from Dick's Creek (ug/L) Compared to Surface Water Screening Values (ug/L).[1,8]					
Analyte	**Maximum Concentration**	**Source**	**Screening Value[2]**	**Hazard Quotient**	**COC?[4]**
PCBs	0.07[5]	AquaQual (2001)	0.014	5	yes
total PAHs	<1 ug/L	Arcadis (2001) Table B-1	analyte-specific[7]	<1	no
Aluminum	8	Arcadis (2001) Table B-1	75[6]	<1	no
Arsenic[3]	6	OEPA (2000c)	150	<1	no
Barium[3]	137	OEPA (2000c)	3.8[6]	>1	no[9]
Cadmium	0.09	Arcadis (2001) Table 5-4	2.2	<1	no
Chromium[3]	2.0	Arcadis (2001) Table 5-4	11	<1	no
Copper	1.95	Arcadis (2001) Table 5-4	9	<1	no
Iron	38.6	Arcadis (2001) Table B-1	158[6]	<1	no
Lead	0.57	Arcadis (2001) Table 5-4	2.5	<1	no
Manganese[3]	273	OEPA (2000c)	80.3[6]	>1	no[9]
Nickel	14.7	Arcadis (2001) Table 5-4	52	<1	no
Silver	0.047	Arcadis (2001) Table B-1	0.12[6]	<1	no
Strontium[3]	1020	OEPA (2000c)	620[6]	>1	no[9]
Zinc	24.5	Arcadis (2001) Table 5-4	120	<1	no

1. Metals concentrations are dissolved if available; total concentrations noted where listed.
2. Screening values are freshwater AWQC (USEPA, 1999) unless otherwise noted. Metal benchmarks were not corrected for water hardness for the screening because no detected concentrations exceeded more conservative default AWQC values.
3. Total detected concentration (dissolved concentration not reported). Chromium screening value is for hexavalent chromium.
4. COC: contaminant of concern if hazard quotient > 1.
5. Highest detected value reported. Multiple non-detections at the most sensitive detection limit of 0.2 ug/L.
6. Lowest value reported by Suter (1996).
7. Screening value for total PAHs not available. Comparison of individual analytes or homolog groups to Suter (1996) screening values indicates all hazard quotients <1.
8. Excludes a few low level (≤10 ug/L) detections of organic analytes by OEPA (2000c) because of unknown toxicity and inconsistent detections: acetone, thiazoles, propanols, butanols, ethanols, propanal, butanal, heptanal, octadecenal, 2,3H-benzothiazolone, squalene, vitamin E, phenols, 1,3-dihydro-2H-indol-2-one, hexanoic acid, decanoic acids and esters, nitriles, o-hydroxybiphenyl, chloroform, phytol, 1-octadecene, 2-butanone, bromodichloromethane, nonanoic acid, xylenes, phthalates, oxetanone, and acetaldehyde. Pesticides were detected at less than 0.01 ug/L: BHCs, endosulfan, hexachlorobenzene, endrin, and heptachlors. A few chemicals were infrequently detected at greater than 10 ug/L: 2-butoxyethanol (20 ug/L), one decanoic acid (30 ug/L), and a compound listed as benzo[1,2-c:3,4-c':5,6-c"]tris[1,3,5]ox (≤80 ug/L). These chemicals were considered to be at trace levels and not site related.
9. Not considered a COC for quantitative evaluation because reported concentration is a total rather than dissolved measurement. Discussed in the uncertainty section.

A6. Flood Plain Soil

Table A6. Screening of Risks to Wildlife Consuming Earthworms or Small Mammals Using Maximum Detected Contaminant Concentrations in of PCBs in Surface Soil of the Dick's Creek Flood Plain.[1]

Prey	PCBs in Soil (mg/kg dw)	BAF	Prey PCBs (mg/kg dw)	Prey PCBs (mg/kg ww)[3]	Wildlife Screening Value[4] (mg/kg ww)	Hazard Quotient
earthworm	0.17	15.91[2]	2.71[3]	0.434	0.71	<1
small mammal	0.17	1.78[5]	NA[5]	0.303	0.71	<1

1. Table 1 of Arcadis (2002). Sample location listed as "Outfall 002 - Monroe Ditch North Side".
2. BAF: soil to earthworm bioaccumulation factor (dry weight earthworm:dry weight soil). 90th percentile value for combined data set from Sample et al. (1999).
3. Conversion of dry weight prey PCBs to wet weight prey PCBs assuming moisture content of earthworms of 84% (Sample et al., 1999).
4. See Table A1.
5. BAF: soil to small mammal bioaccumulation factor (wet weight mammal:dry weight soil). 90th percentile value for omnivore category from Sample et al. (1998). TCDD value used as a surrogate. NA: not applicable (BAF converts prey to ww PCBs).

Appendix B

Wildlife Exposure Parameters

Overview

This Appendix lists the exposure model parameter used in assessing risks to wildlife. Only those pathways and wildlife receptors that were determined from the risk screening (Appendix A) are included: kingfisher, raccoon, and mink. See report text for explanation.

B1. Kingfisher

Table B1. Ranges of exposure parameter values for the belted kingfisher.[1]

Parameter	Symbol	Units	Range	Notes
Body weight	BW	kg (ww)	0.147	
Ingestion rate	IRwet	kg/d (ww)	0.058	
	IRdry	kg/d (dw)	0.017	
Water Consumption	WI	L/d	0.016	
Diet Composition	PD	%	fish: 78 AI[2]: 22 IS[2]: 1	
Area Use Factor[3]	AUF	unitless	1	AH: 8 HR: 0.7 km
Exposure Duration[4]	ED	unitless	1	

1. Values from Table 3-23 of USEPA (2002) unless indicated. All mass units in wet weight.
2. AI: aquatic invertebrates; IS: incidental sediment ingestion.
3. AUF calculated from the spatial extent of affected site habitat divided by species-specific home range: AUF = AH/HR. AH (affected habitat) determined from length of affected stream (5 miles); see report Section 4; HR (home range) determined from USEPA (2000).
4. ED = sum of temporal correction factors in USEPA (2000).

B2. Raccoon

Table B2. Ranges of exposure parameter values for the raccoon.[1]				
Parameter	**Symbol**	**Units**	**Range**	**Notes**
Body weight	BW	kg	6.4 - 7.6	Female - male
Ingestion rate	IRwet	kg/d	0.99 - 1.2	Female - male
	IRdry	kg/d	0.316 - 0.364	
Water Consumption	WI	L/d	0.526 - 0.614	Female - male
Diet Composition	PD	%	fish: 3 AI[2]: 37 NR[2]: 60 IS[2]: 9.4	
Area Use Factor[3]	AUF	unitless	1	AH: 49[5] HR: 48 hectares
Exposure Duration[4]	ED	unitless	1	

1. Values from Table 3-68 of USEPA (2002) unless indicated. All mass units in wet weight.
2. AI: aquatic invertebrates; NR: non-river sources; IS: incidental sediment ingestion.
3. AUF calculated from the spatial extent of the affected site habitat devided by the species specific home range: AUF = AH/HR. AH (affected habitat) determined from estimated surface area of affected area; see Report Section 4 and footnote 4; HR (home range) determined from USEPA (2000).
4. ED = sum of temporal correction factors in USEPA (2000).
5. Calculated from estimated habitat area of 5 miles of river length and an average of 0.037 mile width of river/flood plain/riparian area.

B3. Mink

Table B3. Ranges of exposure parameter values for the mink.[1]				
Parameter	**Symbol**	**Units**	**Range**	**Notes**
Body weight	BW	kg	0.83 - 1.02	Female - male
Total Daily Ingestion	IRwet	kg/d	0.132	
	IRdry	kg/d	0.059 - 0.069	
Water Consumption	WI	L/d	0.084 - 0.101	Female - male
Diet Composition	PD	%	fish: 34 AI[2]: 16.5 NR[2]: 49.5 IS[2]: 1	
Area Use Factor[3]	AUF	unitless	1	AH: 8 HR: 1.9 to 3.4 km
Exposure Duration[4]	ED	unitless	1	

1. Values from Table 3-69 of USEPA (2002) unless indicated. All mass units in wet weight.
2. AI: aquatic invertebrates; NR: non-river sources; IS: incidental sediment ingestion.
3. AUF calculated from the spatial extent of the affected site habitat devided by the species specific home range: AUF = AH/HR. AH (affected habitat) determined from estimated length of affected stream (5 miles; see Report Section 4); HR (home range) determined from USEPA (2000).
4. ED = sum of temporal correction factors in USEPA (2000).

AK5 039900

Appendix C

Derivation of Wildlife Screening Values for PAHs

Overview

This Appendix provides the derivation of total polycyclic aromatic hydrocarbon (tPAH) screening values for birds and mammals. These screening values were derived because appropriate tPAH dietary benchmarks for wildlife were not available in Sample et al. (1996) or other standard reference sources.

Table C1. Derivation of Wildlife Dietary Wildlife Screening Values for Total Polycyclic Aromatic Hydrocarbons (tPAH).

Parameter	Bird	Mammal
Reference article	Mazet et al. (2001)	Patton and Dieter (1980)
Test species	mallard	mink
Dietary test material	PAH mixture (low MW)[1]	Alaska North Slope crude oil
Test duration	7 months	60 d prior to breeding to kit weaning
Life stage tested	subadults	lifecycle
Endpoints	growth, organ weight	P1 survival, reproduction F1 survival, reproduction
Test Concentrations	0, 400, 4000 mg/kg diet (ww)	0, 500 mg/kg diet (ww)
Significant Effects	LOEC: 400 mg/kg (growth reduction, organ enlargement)	LOEC: 500 mg/kg (reduced reproductive success, kit survival, F1 reproductive success)
LOEC adjustment	20 (low MW PAH mixture; no reproductive endpoint)	20 (severe effects at test LOEC)
LOEC TRV:	20 mg/kg diet (ww)	25 mg/kg diet (ww)
NOEC TRV:	2 mg/kg diet (ww)	2.5 mg/kg diet (ww)

1. Test mixture contained only low molecular weight (MW) PAHs (2 and 3 rings).

AK5 039902

Appendix D

June 2002 Site Visit Summary and Photographs

AK5 039903

Overview

Mace Barron visited on-site and off-site areas (described in the observations below) of Dick's Creek and the AK Steel site on June 5, 2002, along with representatives of the US Department of Justice, Ohio EPA, USEPA, and AK Steel. Mace Barron made observations and took eight off-site photographs of Dick's Creek and warning signs (provided below). AK Steel did not allow photographs on-site or at Monroe Ditch.

Ecological Risk Assessment Observations

Ecological observations included the following:

- Water was flowing in a drainage channel running east to west that entered Monroe Ditch near the southern site boundary. The channel appeared to be down gradient of the former contaminated ponds and may have been a source of historical PCB entry.

- Monroe Ditch appears to have heavy flows at times, as evidenced by the large upstream culverts at the railroad tracks and waste high stream debris at the stream bank near the culverts.

- A mallard duck was in Monroe Ditch just upstream of the site property.

- Monroe Ditch appears to serve as aquatic habitat, as evidenced by multiple pools and riffles, an established riparian corridor on both stream banks, and small birds and dragon flys (species not identified) present in the riparian corridor. Several areas of the stream appeared to be deep enough to support small fish.

- OEPA commented that Monroe Ditch was classified as a water of Ohio and was considered to be aquatic habitat.

- The interceptor trench only captured groundwater flows on the east back of Monroe Ditch. The interceptor trench, as was described by AK Steel, appeared to not intercept all potentially contaminated flows on the east side of Monroe Ditch.

- A seep was evident below the interceptor trench, and T. Barber (AK Steel contractor) indicated that PCBs had been detected at that location.

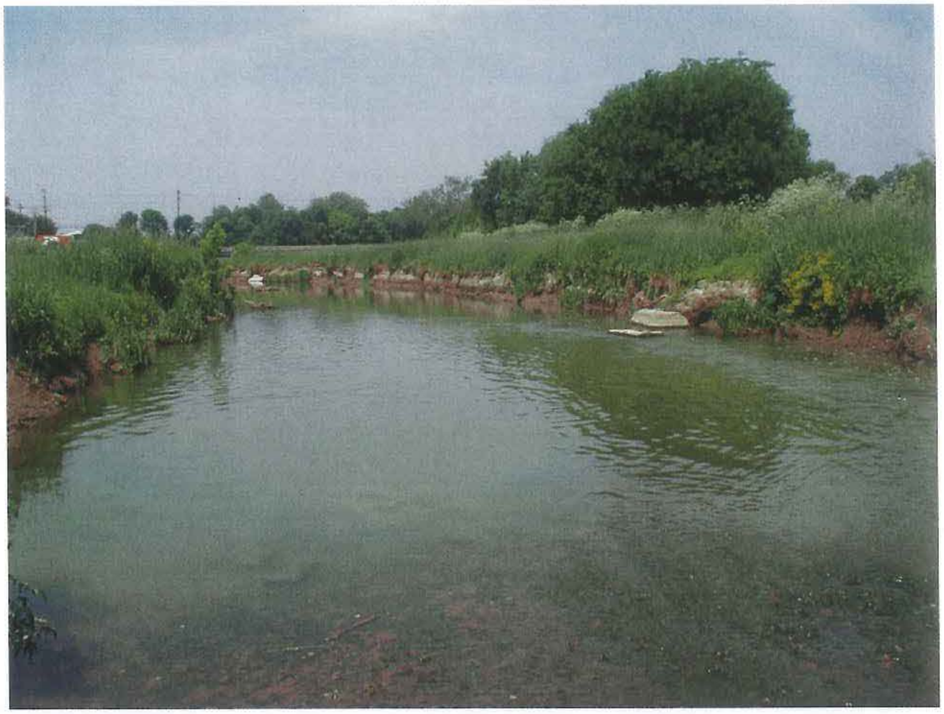
- A channel on the west side of the landfill (west of Monroe Ditch near western AK property line) contained water, but was not flowing.

- Petroleum contamination in sediment was evident at the mouth of Monroe Ditch. Rainbow sheening and petroleum odor were produced when the sediment was disturbed, and a sheen flowed into Dick's Creek.

- A partially fallen warning sign (no bathing, fish, drinking) near Monroe Ditch was photographed. Waist high stream debris on the sign indicated that Dick's Creek was subject to high flows that submerge the flood plain.

- Dick's Creek was channelized near Monroe Ditch, and sediments had filled the former concrete channel. The flood plain consisted of sandy soils and abundant vegetation that would likely support amphibians and wildlife. Racoon and deer tracks were evident near the mouth of Monroe Ditch, and a hawk was observed in the area. Photographs were taken looking upstream and downstream on Dick's Creek near Monroe Ditch.

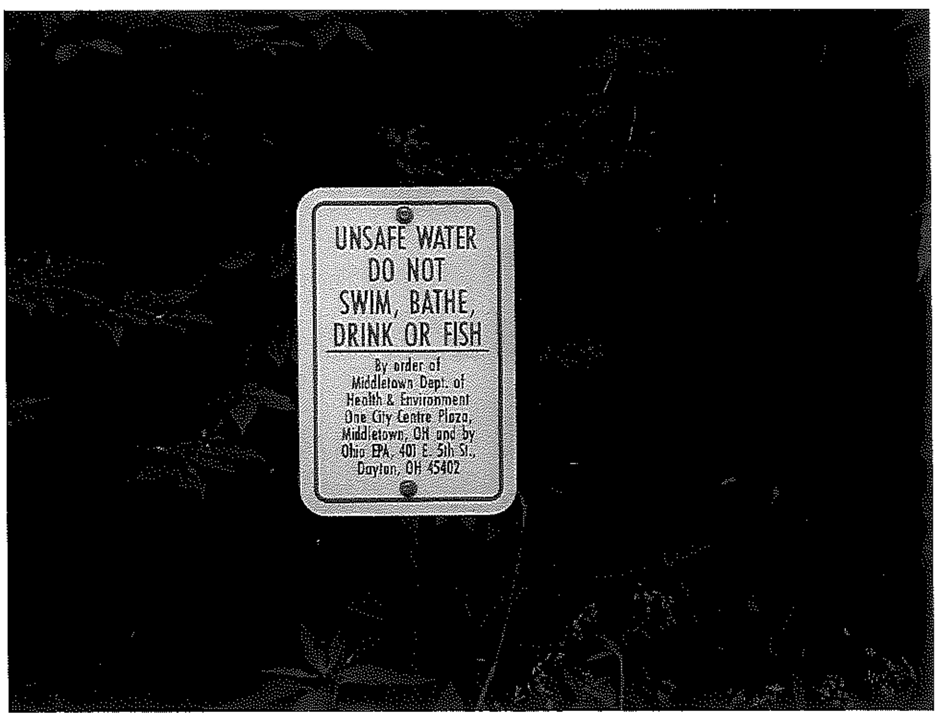
- Two additional sections of Dick's Creek were observed: near the trailor park (~1.25 miles downstream of Monroe Ditch; channelized area) and Amanda Grammar School (~0.75 miles downstream of Monroe Ditch; natural channel with established riparian area). Both stream areas were photographed.



Dick's Creek looking downstream from rail road bridge and Monroe Ditch (Photos 1 and 2).

Dick's Creek looking upstream from rail road bridge (Photo 3; top) and floodplan vegetation and sign near Monroe Ditch (Photo 4; bottom).

Dick's Creek looking upstream near trailor park (Photo 5; top) and near Amanda school (Photo 6; bottom).



Dick's Creek near Amanda school showing stream channel (Photo 7) and sign in proximity to creek (Photo 8; bottom).

Appendix E

Exposure Data

AK5 039910

Overview

This Appendix provides exposure data for PCBs in sediment, surface water, aquatic plants, benthic invertebrates, and fish.

AK5 039911

E1. Sediment

Table E1. PCBs in Surface Sediment from Dick's Creek (mg/Kg dw) Collected during 2000 and 2001 (Arcadis, 2001b).[1,4]			
Sample ID	**PCBs[2]**	**River Mile[3]**	**Collection Date**
DCSD01B	0.16	0.12	February, 2001
DCSD03	0.05	0.25	January, 2001
DCSD04	0.03	0.53	January, 2001
DC27s	3.53	0.85	September, 2000
DCSD05	0.24	0.9	January, 2001
E	0.05	1.0	September, 2000
DC26	0.03	1.03	September, 2000
DCSD06	1.33	1.1	January, 2001
DCSD07	0.99	1.42	January, 2001
D	1.59, 0.01	1.5	September, 2000
DCSD08	0.58	1.64	January, 2001
DCSD09A	0.33	1.92	January, 2001
DCSD10	0.08	2.0	January, 2001
DCSD11	1.16	2.1	February, 2001
DCSD12	0.06	2.3	February, 2001
DC-16s	0.02	2.34	September, 2000
DCSD13	0.03	2.45	January, 2001
C	0.19	2.5	September, 2000
DCSD14	0.01	2.53	January, 2001
DCSD15	0.02	2.72	January, 2001
B	0.02	2.76	September, 2000
DCSD16	0.19	2.82	January, 2001
DCSD17	0.36	3.05	January, 2001
02SD01	0.68	3.08	January, 2001

DC-09s	0.27	3.085	September, 2000
DCSD18	0.01	3.26	January, 2001
DCSD19	0.01	3.54	January, 2001
DC-04s	0.01	3.64	September, 2000
DCSD20	0.01	3.8	January, 2001
DCSD21	0.01	4.14	January, 2001
DCSD22	0.01	4.2	January, 2001
A	0.004	4.33	September, 2000
DCSD23	0.01	4.56	January, 2001
DCSD24	0.01	4.75	January, 2001
DCSD25	0.01	5	January, 2001

1. Surface sediment data (0-6 inches) from Table 3 of Arcadis (2001b). Data are total PCBs normalized to 1% total organic carbon.
2. Mean value if multiple samples collected at same date and location.
3. Estimated from Arcadis (2001a) Figure 3-1.
4. Additional sediment data used in the ecological risk assessment were from OEPA (2000a), and are shown in Figure 4.3.

E2. Aquatic Plants

Table E2. PCBs in Aquatic Plants (mg/kg ww).[1,2]		
Location[3]	**PCBs (mg/kg ww) October 1999**	**PCBs (mg/kg ww) August, 2000**
A	ND (0.005)	ND (0.033)
B	ND (0.005)	0.284
C	0.010	0.207
E	ND (0.005)	0.057

1. Table B-5 of Arcadis (2001a). Plants are *Elodea spp.* (p. 18 of Arcadis, 2001a).
2. ND: not detected. Value in parentheses is one half of reported detection limit.
3. Approximate Dick's Creek river mile (estimated from Figure 3-1 of Arcadis (2001a): location A (4.33), location B (2.76), location C (2.5), location D (1.5), location E (1).

E3. Benthic Invertebrates

Table E3-1. PCBs in benthic invertebrates from Dick's Creek (mg/kg ww).				
Species	**PCBs**	**Collection Location**[3]	**Collection Date**	**Data Source**
Corbicula	1.62	Amanda	August, 2000	AquaQual (2001)[1]
Corbicula	0.647	USGS	August, 2000	AquaQual (2001)[1]
Corbicula	2.02	Amanda	October, 1999	AquaQual (2001)[1]
Corbicula	1.08	Beaver Dam	October, 1999	AquaQual (2001)[1]
Oligochates	0.011	Confluence with North Branch	October, 1999	AquaQual (2001)[1]
crayfish	0.04[4]	Location A	August 2000	Arcadis (2001)[2]
crayfish	2.462	Location B	August 2000	Arcadis (2001)[2]
crayfish	0.302	Location C	August 2000	Arcadis (2001)[2]
crayfish	0.124	Location D	August 2000	Arcadis (2001)[2]
crayfish	1.086	Location E	August 2000	Arcadis (2001)[2]
Odonates	0.04[4]	Location A	October, 1999	Arcadis (2001)[2]
Odonates	0.126	Location B	October, 1999	Arcadis (2001)[2]
Odonates	0.123	Location C	October, 1999	Arcadis (2001)[2]
Odonates	0.098	Location D	October, 1999	Arcadis (2001)[2]
Odonates	0.161	Location E	October, 1999	Arcadis (2001)[2]

1. Invertebrates samples reported in the Excel shreadsheet "Dick's new ERA data". In situ data excluded because of PCBs detected in laboratory controls (e.g., 1 mg/kg ww).
2. Table B-8.
4. Reported Dick's Creek station name. Approximate Dick's Creek river mile: Amanda (1.63), USGS (2.45), Beaver Dam (2.36), North Branch (5.2), location A (4.33), location B (2.76), location C (2.5), location D (1.5), location E (1). Locations A to E estimated from Figure 3-1 of Arcadis (2001a); other station river miles determined from AquaQual (2001).
5. Not detected: value is one half of reported detection limit.

Table E3-2. Planar PCBs in Indigenous Invertebrate Tissue Collected in 1999 and 2000 (AquaQual, 2001). [1,2]

Congener	Below Outfall 002	Above Outfall 002
77	3.6 - 10.3	ND
81	0 - 1.9	ND
105	9.7 - 10.9	ND
114	0 - 0.72	ND
118	24.3 - 28.7	1.8
123	2.5 - 3.6	ND
126	ND	ND
156	ND - 2.1	ND
157	ND - 0	ND
167	NA	NA
169	ND - 0	ND
189	ND	ND

1. ND: not detected (detection limit not reported); NA: not analyzed or combined results with another non-planar congener.
2. Source: WSU/AquaQual Excel spreadsheet "Dick's new ERA data".

Table E3-3. Planar PCBs and World Health Organization (USEPA, 1998b) Toxicity Equivalency Factors (TEFs).				
Congener	**Chlorines**[1]	**Fish TEF**	**Bird TEF**	**Mammal TEF**
77	4	0.0001	0.05	0.0001
81	4	0.0005	0.1	0.0001
105	5	<0.000005	0.0001	0.0001
114	5	<0.000005	0.0001	0.0005
118	5	<0.000005	0.00001	0.0001
123	5	<0.000005	0.00001	0.0001
126	5	0.005	0.1	0.1
156	6	<0.000005	0.0001	0.0005
157	6	<0.000005	0.0001	0.0005
167	6	<0.000005	0.00001	0.00001
169	6	0.00005	0.001	0.01
189	7	<0.000005	0.00001	0.0001
1. Number of chlorines in congener.				

E4. Fish

Table E4-1. Arcadis (2001a) PCB Concentrations in Fish (mg/kg ww).[1]					
Fish Category	**Species**	**Length (cm)**	**PCBs**	**Sample Location[4]**	**Collection Date**
small fish species	spotfin shiner	NR[2]	0.95[3]	Location A	August, 2000
	spotfin shiner	NR	2.001	Location B	August, 2000
	spotfin shiner	NR	2.517	Location C	August, 2000
	spotfin shiner	NR	4.228	Location D	August, 2000
	spotfin shiner	4.0 - 7.0	2.617	Location E	August, 2000
	spotfin shiner	6.8 - 9.8	0.421	Location A	October, 1999
	spotfin shiner	NR	0.656	Location B	October, 1999
	spotfin shiner	6.5 - 9.2	1.08	Location C	October, 1999
	spotfin shiner	6.0 - 10.7	1.91	Location D	October, 1999
	spotfin shiner	NR	4.419	Location E	October, 1999
medium fish species	longear sunfish	9.0 - 13.0	0.256	Location A	August, 2000
	longear sunfish	9.5 - 11.8	2.093	Location B	August, 2000
	longear sunfish	10.0 - 12.7	1.625	Location C	August, 2000
	longear sunfish	11.0 - 15.0	8.415	Location D	August, 2000
	green sunfish	9.5 - 15.0	2.337	Location E	August, 2000

	longear sunfish	10.0 - 12.6	1.15	Location A	October, 1999
	longear sunfish	NR	5.39	Location B	October, 1999
	longear sunfish	11.1 - 13.5	2.904	Location C	October, 1999
	longear sunfish	8.9 - 11.7	3.703	Location D	October, 1999
	longear sunfish	9.8 - 10.6	5.82	Location E	October, 1999
large fish species	carp	41.0 - 47.8	22.9	2.6 river miles	September, 1998
	white sucker	30.3 - 32.5	7.12	2.6 river miles	September, 1998

1. Arcadis (2001) Table B-11.
2. NR: not reported.
3. Reported as one half of detection limit.
4. Locations A to E estimated from Figure 3-1 of Arcadis (2001a).

Table E4-2. Ohio EPA (OEPA, 2000b) PCB Concentrations in Whole Fish (mg/kg ww).					
Fish Category	**Species**	**Length (cm)**	**PCBs**	**Sample Location (river mile)**	**Collection Date**
medium fish species	creek chub	12.7 - 13.2	3.612	1.7	October, 2000
	longear sunfish	10.5 - 11.9	5.955	1.7	October, 2000
	longear sunfish	8.8 - 12.5	2.971	2.6	October, 2000
	creek chub	15.6 - 18.2	3.439	2.8	October, 2000
	longear sunfish	8.3 - 10.6	1.812	2.8	October, 2000
large fish species	Yellow bullhead	17.9 - 20.7	3.832	1.7	October, 2000
	Carp	27.1	7.129	1.7	October, 2000
	White sucker	26.2 - 30.9	2.465	1.7	October, 2000
	Carp	31.0 - 37.2	7.584	2.6	October, 2000
	White sucker	17.6 - 33.1	1.080	2.6	October, 2000
	Carp	26.3 - 28.8	1.827	2.8	October, 2000
	White sucker	26.2 - 30.3	0.569	2.8	October, 2000